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ABSTRACT

This manual was developed to assist teachers in Oklahoma in preparing students for industrial mechanical maintenance. The materials in this teacher's guide are organized in 14 units of instruction covering the following four areas: receiving and setting equipment; equipment hookup and operation; equipment layout, anchoring, and setup; and maintenance. Each unit follows a standardized format that includes eight basic components: performance objectives, suggested activities for the teacher, information sheets, assignment sheets, job sheets, transparency masters, tests, and answers to tests and assignment sheets. (Depending on the specific objectives, transparency masters, assignment sheets, and job sheets may or may not be included in the unit of instruction.) All of the unit components focus on measurable and observable learning outcomes. Units of instruction are designed for use in more than one lesson or class period. (KC)

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INDUSTRIAL MECHANICAL MAINTENANCE

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Developed as a cooperative project by
The Associated General Contractors of America
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and
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John Folks, Chairman
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FOREWORD

Leaders in the construction industry face an endless challenge when training workers. In an effort to promote high-quality and uniform training programs in this industry, representatives of the Associated General Contractors of America entered into an agreement with the Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center to develop training materials. Since 1973 twelve AGC-CIMC manuals have been developed, distributed, and used in local chapters and vocational education.

This instructional manual was designed to complete the Industrial Technology series recently developed by the CIMC.

The purpose of this manual is to assist instructors in providing a high caliber instructional program. Although the format reflects the organization of a systematic approach to instructional materials development and the latest in educational technology innovations, the information should be adapted and modified to coincide with local conditions. Lastly, it is intended that the materials be coupled with the instructor's own methods, experience, and additional materials to make the training process complete.

Dr. Francis T. Tuttle, Director
Oklahoma State Department of
Vocational and Technical Education

PREFACE

For many years contractors and those responsible for training have felt the need for instructional materials to be used in the training process. The Associated General Contractors of America, with the cooperation and support of the Oklahoma State Department of Vocational and Technical Education, Curriculum and Instructional Materials Center, accepted the challenge to produce a manual for use in training industrial mechanical maintenance workers.

Instructional material in this manual is written in terms of student performance using measurable behavioral objectives. This is an innovative process. Criterion-referenced evaluation instruments provide for a uniform measurement of student progress.

Today's instructors are faced with the challenge of providing students with the skill and related information necessary to meet the demands of a changing profession. Competition for jobs is greater than ever. Therefore, the worker must be better trained and better equipped to find and retain meaningful employment.

The purpose of this manual is to assist instructors in providing instruction throughout the industry. This publication should be supplemented by each instructor's methods and materials. Any information in this manual that does not concur with the instructor's course of study can very easily be modified to meet personal needs.

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INDUSTRIAL MECHANICAL MAINTENANCE

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USE OF THIS PUBLICATION

Instructional Units

Industrial Mechanical Maintenance materials include fourteen instructional areas. A standard format was established for development of instructional materials for all Oklahoma vocational teachers. This format includes eight basic components which form a unit of instruction: performance objectives, suggested activities for teacher, information sheets, assignment sheets, job sheets, transparency masters, tests, and answers to tests and assignment sheets. Depending on the specific objectives, transparency masters, assignment sheets, and job sheets may or may not be included in the unit of instruction.

All of the unit components "zero in" toward measurable and observable learning outcomes. Teachers are encouraged to supplement, personalize, localize, and motivate with these materials in order to develop a complete teaching-learning process.

Units of instruction are designed for use in more than one lesson or class period of instruction. Careful study of each unit of instruction by the teacher will help determine:

A. Amount of material that can be covered in each class period
B. Skills which must be demonstrated
    1. Supplies and equipment needed
    2. Amount of practice needed
    3. Amount of class time needed for demonstration
C. Supplementary materials, such as pamphlets and filmstrips, that must be ordered
D. Resource people who must be contacted

Performance Objectives (white pages)

Each unit of instruction is based on the performance needed for successful employment in an occupational area. Performance objectives are stated in two forms: unit objectives, stating the subject matter to be covered in a unit of instruction; and specific objectives, stating the student performances necessary to reach the unit objective.

Since the objectives of the unit provide direction for the teaching-learning process, it is important that the teacher and students have a common understanding of the intent of the objectives. Following is a list of performance terms, their meanings, and behavioral synonyms which may have been used in this material:

A. Name--The individual supplies a name for objects, events, or people

    Behavioral synonyms: Label, list, letter, record, reiterate, repeat, write

B. Identify--The individual selects a named, described, or pictured object by pointing to it, touching it, picking it up, or selecting it

    Behavioral synonyms: Select, mark, match, choose, judge

C. State a rule--The individual communicates a relationship or principle which could be used to solve problems or perform a task

D. Apply a rule--The individual supplies an answer to a problem by using a stated relationship or principle

Behavioral synonyms: Solve, calculate

E. Describe--The individual relates sufficient characteristics or properties of an object or event so that a second individual will be able to state what is being discussed

Behavioral synonyms: Define, discuss, interpret, recite, tell how, tell what happens when

F. Distinguish--The individual selects an object or event from two or more which are easily confused

Behavioral synonyms: Discriminate, differentiate

G. Order--The individual arranges three or more objects or events in a sequence based on a stated property

Behavioral synonyms: Arrange, sequence, list in order, classify, divide, isolate, sort

H. Construct--The individual makes a physical object, a verbal statement, or a drawing

(NOTE: Construct is used when the finished product or result is important.)

Behavioral synonyms: Draw, make, build, design, formulate, reproduce, transcribe, convert, put together, compile

I. Demonstrate--The individual performs several operations necessary to carry out a specified process

(NOTE: Demonstrate is used when it is desirable to watch the student perform a task, one of the highest levels of student performance.)

Behavioral synonyms: Show your work, show procedure, perform an experiment, perform the steps, operate, remove, replace, turn off/on, (dis) assemble, (dis) connect

The objectives should be provided for students and stressed throughout the teaching-learning process. This will help answer any questions concerning performance requirements for each instructional units. The objectives can also help determine teaching strategies and instructional methods. Prepare for each unit by deciding how each objective can best be taught.

The objective sheet may be also used as a quick pretest to determine prior knowledge of students and if further study or activities are necessary. Teachers should feel free to modify, delete, or add objectives in order to meet the needs of the students and community. When changes in objectives are made, the teacher should remember to supply the needed information, assignment and/or job sheets, and criterion test items.

Suggested Activities (pink pages)

This component is included only in teacher material. The suggested activities page assists teachers during the preparation stage of the teaching-learning process by providing suggestions for delivery and/or presentation during the instructional process. Read the suggested activities before teaching the units so supplemental materials can be obtained, audio-visual materials prepared, and outside resources contacted. Duties of the teacher will vary according to the particular unit.

The references that are listed are ones used in the development of each unit. They should be used by teachers to supplement their knowledge of the subject area or to help students with particular interest or occupational objective in the area covered.

Information Sheet (green pages)

The information sheet provides "must know" content essential for meeting the cognitive (knowledge level) objectives of the unit. The information is written in a topical outline form and is keyed to the specific objectives.

Teachers will find that the information sheet serves as an excellent guide for presenting background knowledge necessary to develop the skills specified in the unit objective. The information sheet may also be used for coordination activities and advisory committees.

Students should read the information sheet before the information is discussed in class. Space is provided in margins for students and teachers to add notes that supplement, localize, personalize, and provide motivation for each unit.

Transparency Masters (white pages in teacher material and green in student material)

Transparency masters provide information in a special way. The students may see as well as hear the material being presented, thus reinforcing the learning process. Transparencies may present new information or they may reinforce information presented in the information sheet. They are particularly effective when identification is necessary.

Transparencies should be made and placed in the notebook where they will be immediately available for use. Transparencies direct the class's attention to the topic of discussion. It is recommended that teachers stand away from the overhead projector when discussing transparency material to avoid speaking too loudly.

Assignment Sheets (brown pages)

Assignment sheets give students a chance at problem solving, self-assessment, and/or practical experience with the information. They assist students in the application of knowledges which are necessary prerequisites to skill development. These may be given to the student for completion in class or used for homework assignments. Answer sheets are provided when appropriate and can be used by the student and/or teacher for checking student progress.

Job Sheets (blue pages)

Job sheets are another important segment of a unit of instruction. The job sheets provide a list of equipment, tools, and materials needed to complete a manipulative or psychomotor skill. They describe a step-by-step procedure needed to complete each task or job. Diagrams, photographs, and illustrations are provided to assist students in achieving the skill.

A teacher should demonstrate to students the procedures outlined in each job sheet. Furthermore, the teacher needs to localize the job sheet accordingly, to the equipment and supplies available in the local lab or shop situation. Job sheets also furnish potential employers with a picture of the skills being taught and the performances they might reasonably expect from a person who has had this vocational instruction.

Tests (yellow pages)

This component provides criterion-referenced evaluation of every objective listed in the unit of instruction. It is crucial to note that both paper-pencil and performace objectives must be evaluated.

The tests may be written or oral. It is recommended that the tests be divided into shorter tests covering three or four objectives at a time and given soon after those objectives have been covered. A selection of questions from the units covered may be used for final tests at the end of each term if desired. If objectives have been added, deleted, or modified, be sure to make the changes on the test.

The acceptable response on a unit test, eighty-five percent in most units, may be raised or lowered to fit the topic or students' ability levels. The percentage applies to the overall score, not to each individual question. The final unit grade should be obtained by using the "paper-pencil" score along with teacher evaluations of student demonstrations of the desired skills.

Answers to Test and Assignment Sheets (pink pages)

These components are designed to assist the teacher in evaluation of student performances.

Methods of Disseminating Material

Material may be given out a unit or page at a time to keep the material before the students always new. Some teachers ask students to furnish a three-ring binder for the units while studying a particular units. This is more convenient for taking the material home to study. Each unit is then placed in the larger binders upon its completion. The large binders may be purchased from AGC. Some teachers have stored the materials by units in filing cabinets or boxes until needed for use. All the units may be given out at once if desired.

Student materials should be provided for each student for best results. Student materials contain everything but the test answers, answers to assignment sheets, and suggested activities. The tests are collated all together at the back of student material and should be removed and stored until needed. The students should be allowed to take their materials home at the end of the training program.

Teaching Methods

It is a challenge to keep students motivated. Supplement the objectives by providing the "why," personal experiences, and current information. Prepare for each unit by deciding how each objective can best be taught. Allow students to become involved in preparing and planning.

RIGGING AND HOISTING
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify hand signals, accessories used for load lifting, and methods for attaching materials and equipment to the hoist. The student should be able to state the purpose of a safety latch hook, identify types of tackles, list types of come-a-longs, and identify types of hoists. This knowledge will be evidenced by completion of the assignment sheet and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with rigging and hoisting to the correct definitions.
2. Identify types of hand signals.
3. Identify accessories used for load lifting.
4. Identify hitches used for attaching materials and equipment to the hoist.
5. Identify types of knots used in rigging.
6. Complete a chart to determine tensile strength of new rope.
7. Calculate the safe working load of ropes.
8. List safety tips related to rigging and hoisting.
9. Describe a safety latch.
10. Explain spreaders and/or spreader bars.
11. Identify types of tackles.
12. List types of come-a-longs (portable winches).
13. Identify types of hoists.
14. Identify hook lifting devices.

RIGGING AND HOISTING
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and assignment sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet and assignment sheets.

   F. Give test.

II. Instructional materials

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Hand Signals
      2. TM 2--Hand Signals (Continued)
      3. TM 3--Accessories Used for Load Lifting
      4. TM 4--Accessories Used for Load Lifting (Continued)
      5. TM 5--Hitches Used for Attaching Materials and Equipment to the Hoist
      6. TM 6--Types of Knots Used in Rigging
      7. TM 7--Types of Knots Used in Rigging (Continued)
      8. TM 8--Safe Working Load of Rope
      9. TM 9--Safety Latches
      10. TM 10--Computing Tension in Slings
      11. TM 11--Sling Angle and Load Factors
      12. TM 12--Sling Angle
      13. TM 13--Rated Capacity of Swaged 6 x 19 Type, I.P., IWRC
      14. TM 14--Types of Tackles

15. TM 15--Types of Tackles (Continued)
16. TM 16--Types of Come-A-Longs (Portable Winches)
17. TM 17--Types of Hoists
18. TM 18--Types of Hoists (Continued)
19. TM 19--Types of Hoists (Continued)
20. TM 20--:Types of Hoists (Continued
21. TM 21--Lifting Devices

D. Assignment Sheet #1--Calculate Safe Working Load of Ropes

E. Answers to assignment sheet

F. Test

G. Answers to test

III. Unit references:

A. *Burke Concrete Construction Accessories Catalog No. 600.* Burlingame, California: Burke Concrete Accessories, Inc., n.d.

B. *Hertz Equipment Rental Rate Guide.* Hertz Equipment Rental Corporation, 1970.

C. Training Publications Division of the Naval Personnel Program Support Activity. *Bureau of Naval Personnel Rate Training Manual: Builder 3 and 2. (NAVPERS 10648-F).* Washington, D.C.: U.S. Government Printing Office, 1970.

D. United Rigging Wire Rope Inc., 372 North Rockwell, Bay #4, Oklahoma City, Oklahoma.

E. *Stephens Industrial Supply: General Catalog.* Oklahoma City, OK: Duncan Equipment Co., Inc., 1977.

F. Headquarters, Department of the Army. *Department of the Army Technical Manual: Rigging, TM5-725.* Washington D.C.: U.S. Government Printing Office, 1968.

RIGGING AND HOISTING
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Rigging--Term used in relation to stacking and hoisting material and equipment

   B. Hitches--Ways of fastening slings or chokers to a load

   C. Choker--Short piece of rope, cable, or chain with an eye on each end or an eye on one end and a hook on the other

   D. Bridle--Two-legged sling which supports the load at two or more points or two or more chokers fastened to a common ring

   E. Sling--Sections of rope, cable, belt, or chain fastened together to form a continuous loop

   F. Tag line--Rope used to guide or steady loads

   G. Safety latch hook--Hook with a safety latch

   H. Block--One or more sheaves fitted in a frame supported by a hook or shackle inserted in the strap of the block

   I. Tackle--Assembly of blocks and lines used to gain a mechanical advantage in lifting

   J. Dog off--To set the brakes

   K. Come-a-long--Device used for pulling and/or stretching wire, cable, or rope; often used to secure loads of material

   L. Spreader bar--Long bar designed for large loads; connected from lifting device in the center of bar and has holes or brackets where several attachments can be made to distribute the load evenly

   M. Gin pole--Single pole with guy lines attached at top and secured to an anchor

   N. Guy lines--Ropes, chains, or cables attached to an object to steady, guide, or secure it

   O. Auxiliary hoist--Supplemental hoisting unit with motor, coupling, brakes, gears, drum, ropes, or cables and block to handle lighter loads at faster speeds than provided for main hoist

INFORMATION SHEET

P. Brake--Device to retard or stop motion by means of friction or power

Q. Bridge--That part of crane consisting of girders, railings, shafting, walk, drive, and trucks which carries the trolley and travels in a direction parallel to the runway rails

R. Bridge travel--Horizontal travel of crane parallel to runway rails

S. Bumper--Energy-absorbing device for reducing impact when a moving crane or trolley reaches the end of its travel

T. Hoist--Piece of equipment designed to raise and/or lower heavy loads

U. Hoist motion--Up and down movement of a crane or hoist

V. Lift--Maximum safe vertical distance through which the hook can travel

W. Operator's cab--Compartment from which operator handles the controls

X. Rated load--Maximum load which a hoist or crane is designed and built to carry

Y. Trolley--Unit consisting of frame, trucks, trolley drive, and hoisting mechanism moving on the rails in a direction at right angles to the crane runway

II. Hand signals (Transparencies 1 and 2)

A. Hoist

B. Lower

C. Raise boom

D. Lower boom

E. Swing boom

F. Move slowly

G. Raise boom and lower load

H. Lower boom and raise load

I. Rack

J. Travel

K. Emergency stop

INFORMATION SHEET

L. Stop

M. Dog off load and boom

III. Accessories used for load lifting (Transparency 3 and 4)

A. Choker

B. Sling (round and flat)

C. Bridle

D. Spreader bar

E. Bull chain

F. Chains and accessories (shackles)

IV. Hitches used for attaching materials and equipment to the hoist (Transparency 5)

(CAUTION: The placement of hitches on the load is very critical. Caution must be taken to be sure hitches are made safely.)

A. Slings

1. Choker hitch
2. Basket hitch
3. Inverted basket hitch

B. Chokers

1. Choker hitch
2. Basket hitch
3. Double anchor hitch

V. Types of knots used in rigging (Transparencies 6 and 7)

A. Square knot

B. Sheet bend

C. Bowline

D. Clove hitch

E. Rolling hitch

F. Running bowline

G. Two half hitches

INFORMATION SHEET

H. Round turn and two half hitches

I. Timber hitch and half hitch

J. Scaffold hitch

VI. Tensile strength of new rope

Diameter	Nylon	Dacron	Polyethylene	Polypropylene	Duraplex
1/2"	6,200	4,400	4,100	4,500	6,700
9/16"	8,000	5,700	5,100	5,400	
5/8"	10,000	7,300	6,000	6,600	
3/4"	14,000	10,000	7,500	8,000	14,500
7/8"	19,000	13,600	9,900	10,750	
1"	24,000	16,500	11,000	12,500	31,400
1 1/8"	31,500	21,600	15,000	17,000	
1 1/4"	36,000	24,400	17,300	19,500	

VII. Formula for determining safe working load of ropes according to tensile strength and safety factors (Transparency 8, Assignment Sheet #1)

Formula: Tensile strength ÷ safety factor = Working load

(NOTE: The following chart shows the working loads which may be applied to new rope. The tensile strength and working load decrease with wear.)

Type of Rope	Tensile Strength	Safety Factor	Working Load
1/2" nylon	6,200 lbs	5	1,240 lbs
1/2" polypropylene	4,500 lbs	5	900 lbs
1/2" dacron	4,400 lbs	5	880 lbs
1/2" polyethylene	4,100 lbs	5	820 lbs
1/2" duraplex	6,700 lbs	5	1,340 lbs

VIII. Safety tips related to rigging and hoisting

A. Use personal protective devices, such as goggles, gloves, safety shoes, and hard hats

B. Use tag line to guide and/or steady load

INFORMATION SHEET

C. Do not walk under load

D. Be sure load is balanced properly

E. Do not overload equipment

F. Stand clear when slings are heaved from under loads

G. Be extra cautious around power lines

(CAUTION: There must be a minimum of ten feet between equipment and power lines. Check local requirements.)

H. Make regular visual checks of all hoisting equipment, including pulleys, ropes, and cables

(NOTE: Remove all damaged pulleys, frayed or weak ropes, and cables.)

IX. Safety latch--Hook with a latch that keeps load from accidentally being knocked off (Transparency 9)

(NOTE: Do not exceed maximum load requirements.)

X. Spreaders and/or spreader bars--Devices used to prevent crushing of the load and to lift extra long and heavy loads (Transparencies 10-13)

(CAUTION: Changing angle of sling leg may increase the stress on the sling. Use the safe working loads charts for determining the proper sling to use. Charts may be obtained from most material manufacturers or their representatives.)

XI. Types of tackles (Transparencies 14 and 15)

(CAUTION: Do not exceed safe working load of rope.)

A. Single whip tackle

B. Gun tackle

C. Simple tackle

D. Compound tackle

E. Single luff

F. Twofold purchase

G. Double luff

H. Threefold purchase

INFORMATION SHEET

XII. Types of come-a-longs (portable winches) (Transparency 16)

(NOTE: Be sure to use the come-a-long that is rated for the particular job.)

- A. Cable
- B. Chain

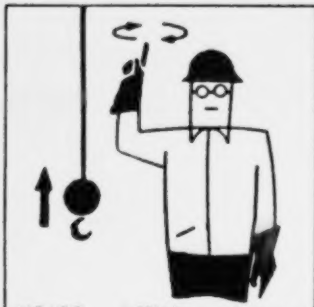
XIII. Types of hoists (Transparencies 17-20)

- A. Cherry picker or personnel lift
- B. Crane
- C. Bridge crane (overhead crane)
- D. Forklift
- E. Jib crane
- F. Floor crane
- G. Stiff leg derrick
- H. Gin pole
- I. Chain hoist (hand)
- J. Chain hoist (electric)
- K. Grip hoist
- L. Hand winch

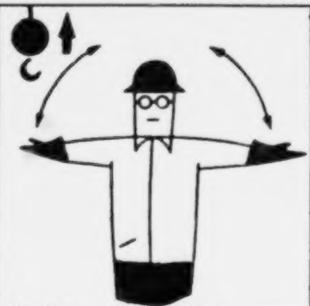
XIV. Hook lifting devices (Transparency 21)

- A. Vertical plate clamp
- B. Horizontal plate clamp
- C. Drum grip
- D. Vertical drum grip
- E. Pipe tong
- F. Beam tong

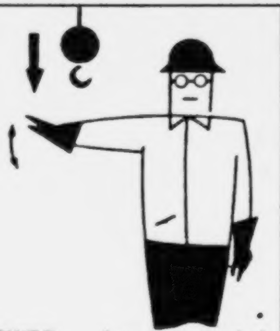
Hand Signals



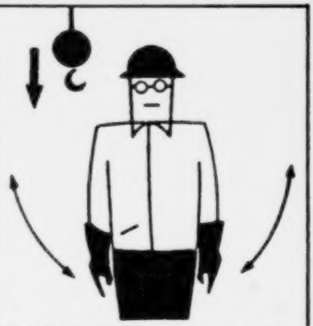
HOIST. With forearm vertical, forefinger pointing up, move hand in small horizontal circle clockwise.



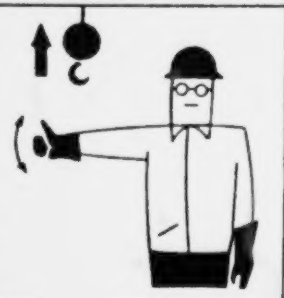
HOIST. Hold both arms horizontal at sides, fully extended, and move upward and return.



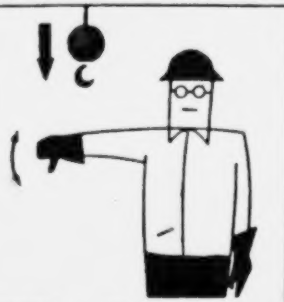
LOWER. Arm extended, palm down, wave hand down and up.



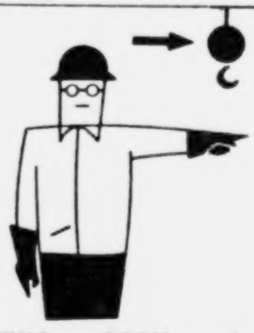
LOWER. Hold arms at sides, fully extended, and move out and return.



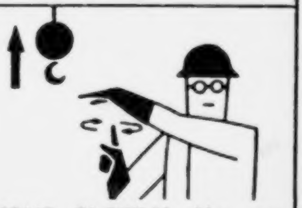
RAISE BOOM. Arm extended, fingers closed, thumb pointing upward, move hand up and down.



LOWER BOOM. Arm extended, fingers closed, thumb pointing down, move hand up and down.



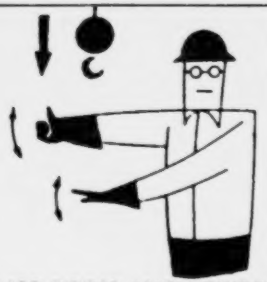
SWING BOOM. Arm extended, point with finger in direction of motion.



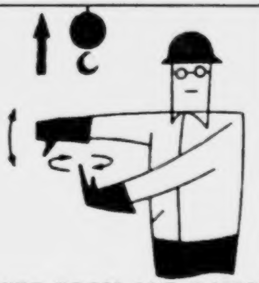
MOVE SLOWLY. Use one hand to give the Hoist, Lower, Raise Boom, Lower Boom, Swing Boom, Travel, or Rack, and place other hand motionless near the hand giving the motion signal. (Hoist Slowly as example.)

Hand Signals

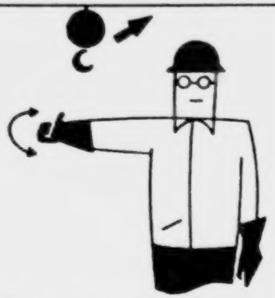
(Continued)



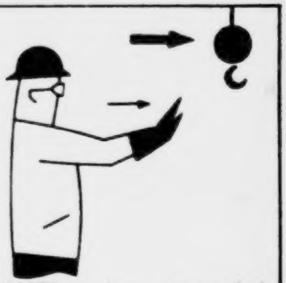
RAISE BOOM AND LOWER LOAD. Give Raise Boom signal with one hand and Lower Load signal with other hand.



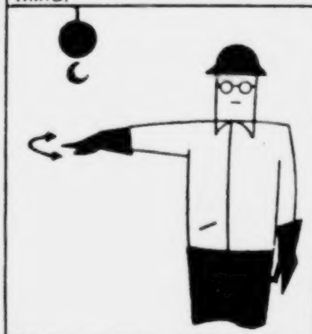
LOWER BOOM AND RAISE LOAD. Give Lower Boom signal with one hand and Raise Load signal with other hand.



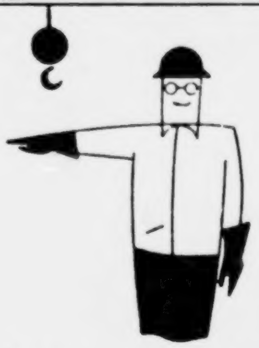
RACK. Palm up, fingers closed, thumb pointing in direction of motion, jerk hand horizontally.



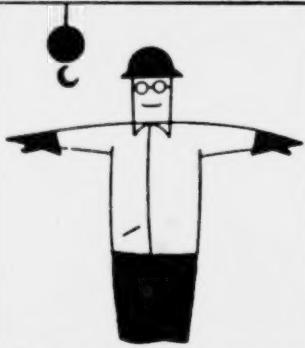
TRAVEL. Arm extended forward, hand open and slightly raised, wave forearm in direction of travel, while facing in that direction.



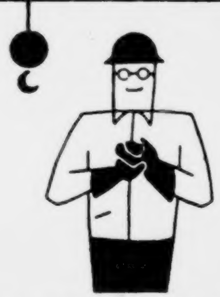
EMERGENCY STOP. Arm extended, palm down, move hand rapidly right and left.



STOP. Arm extended, palm down, hold position rigidly.

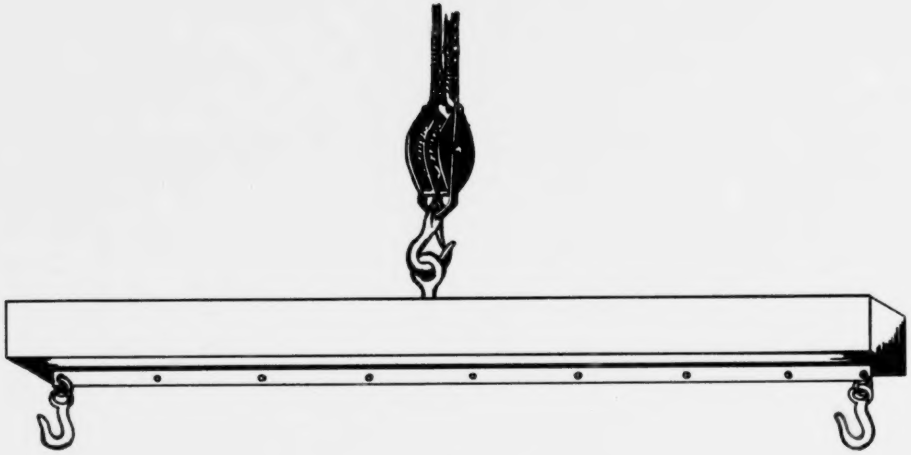


STOP. Hold arms horizontal at sides fully extended.

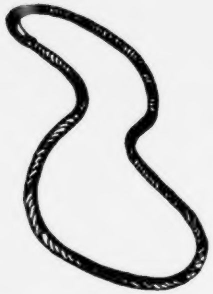


DOG OFF LOAD AND BOOM. Clasp fingers of one hand with fingers of other, palms facing each other.

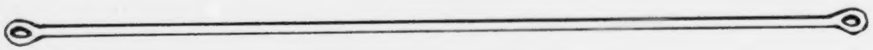
Accessories Used For Load Lifting



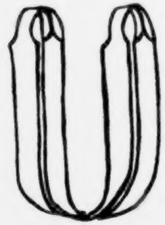
Spreader Bar



Sling

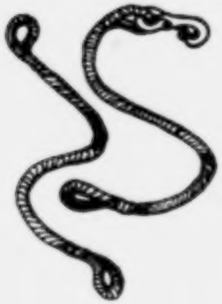


Spreader

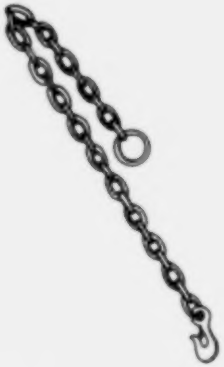


Nylon Webb Sling

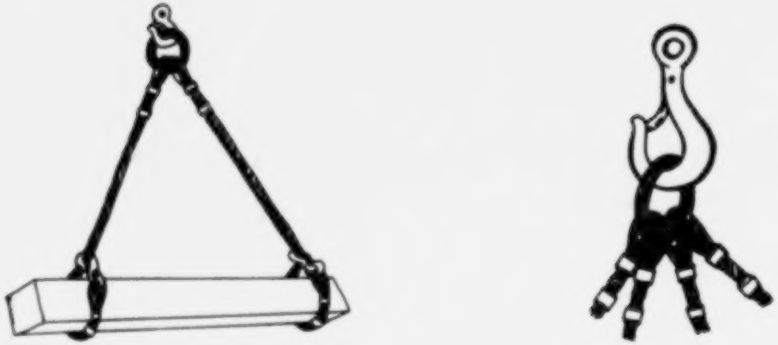
Accessories Used For Load Lifting
(Continued)



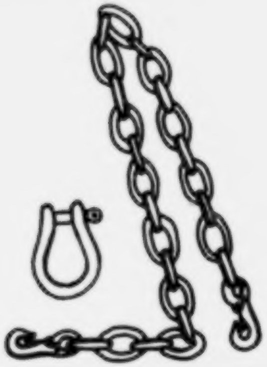
Chokers



Bull Chain



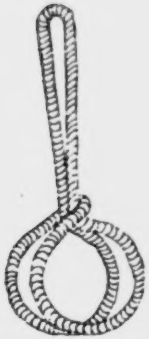
Bridles



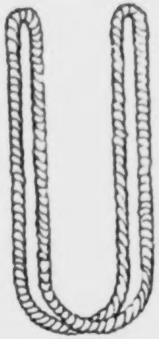
Chain & Accessories

Hitches Used For Attaching Materials And Equipment To The Hoist

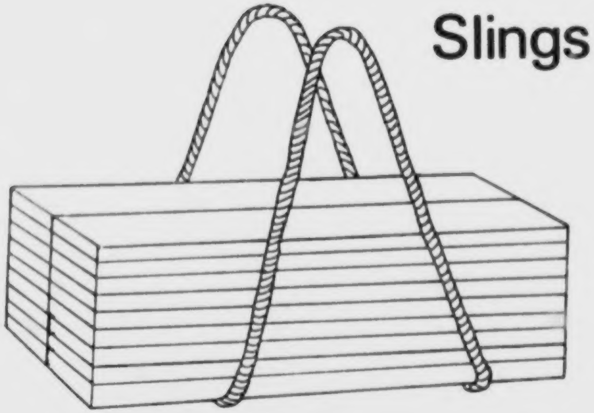
Slings



Choker Hitch

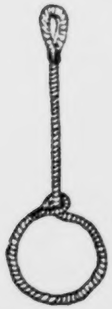


Basket Hitch

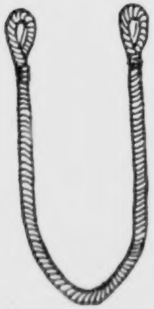


Inverted Basket Hitch

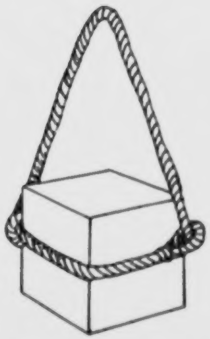
Chokers



Choker Hitch

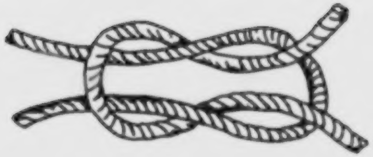


Basket Hitch

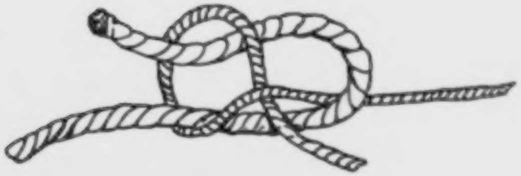


Double Anchor Hitch

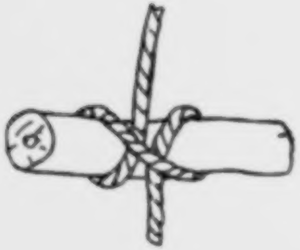
Types Of Knots Used In Rigging



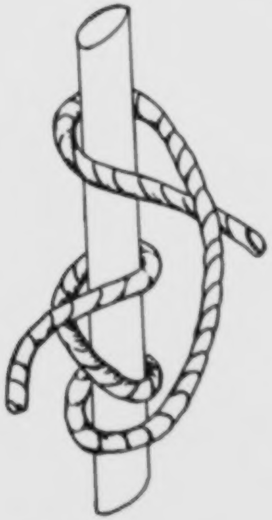
Square Knot



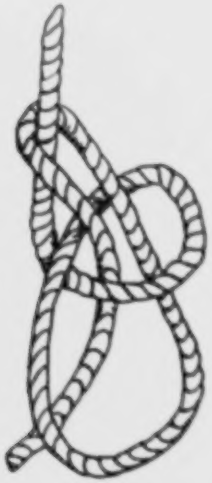
Sheet Bend



Clove Hitch



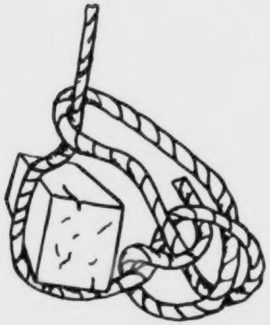
Rolling Hitch



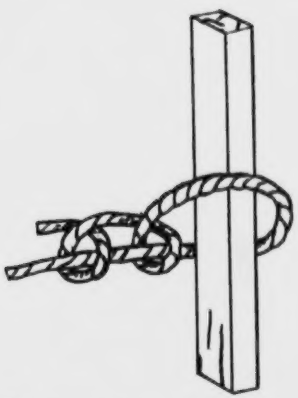
Bowline

Types Of Knots Used In Rigging

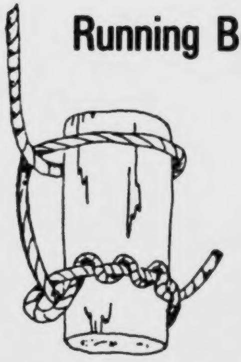
(Continued)



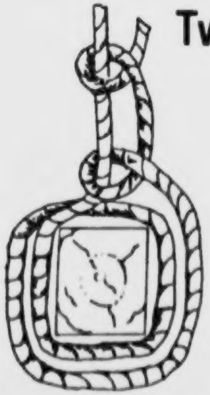
Running Bowline



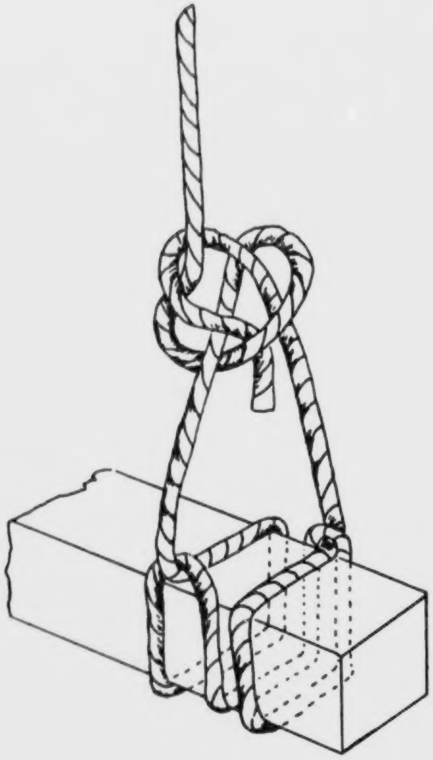
Two Half Hitches



Timber Hitch
And
Half Hitch



Round Turn And
Two Half Hitches



Scaffold Hitch

SAFE WORKING LOAD OF ROPE

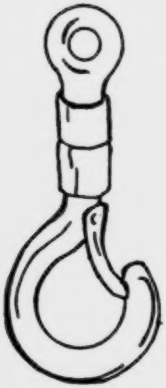
Tensile Strength ÷ Safety Factor = Working Load

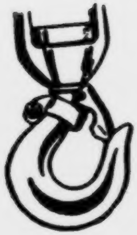
1/2″ nylon tensile strength = 6200 lbs.

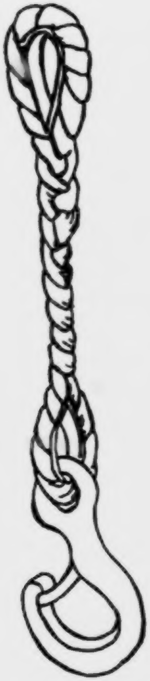
Safety factor = 5

6200 lbs. ÷ 5 = 1240 lbs. Working Load

Safety Latches







COMPUTING TENSION IN SLINGS

Tension in a Sling Leg

$$T = \frac{W_L}{N} \times \frac{L}{V}$$

T = Tension in a Single Leg

W_L = Weight of Load

N = Number of Sling Legs

L = Length of Sling Legs

V = Vertical Distance of Sling

SLING ANGLE AND LOAD FACTORS

Sling Angle	Load Angle Factor
0 (Vertical)	1.000
15°	1.035
20°	1.064
25°	1.104
30°	1.155
35°	1.221
40°	1.305
45°	1.414
50°	1.555
55°	1.742
60°	2.000

SLING ANGLES

Critical Angle--Sling Angle that Exists when the Tension in the Sling Leg Equals the Weight of the Load

Critical Angle Formula

$$CA = \frac{60^\circ}{N}$$

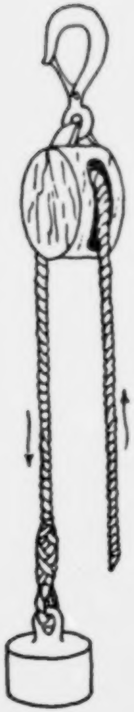
N = Number of Sling Legs

RATED CAPACITY OF SWAGED 6 x 19 TYPE, I.P., IWRC

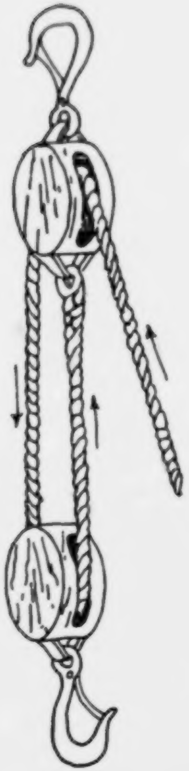
Rope Size in Inches	Rated Capacity (Tons - 2000 lbs.)					
			Basket Hitch			
	Straight Pull	Choker Hitch	Vertical	30°	45°	60°
1/4	.56	.42	1.1	.97	.79	.56
5/16	.87	.65	1.7	1.5	1.2	.87
3/8	1.2	.93	2.5	2.1	1.8	1.2
7/16	1.7	1.3	3.4	2.9	2.4	1.7
1/2	2.2	1.6	4.4	3.8	3.1	2.2
9/16	2.7	2.1	5.5	4.8	3.9	2.7
5/8	3.4	2.5	6.8	5.9	4.8	3.4
3/4	4.9	3.6	9.7	8.4	6.9	4.9
7/8	6.6	4.9	13.0	11.0	9.3	6.6
1	8.5	6.4	17.0	15.0	12.0	8.5
1⅛	10.0	7.8	21.0	18.0	15.0	10.0

(NOTE: Rated loads are based on a radius of curvature of 20 times the individual rope diameter at points of sling contact with load.)

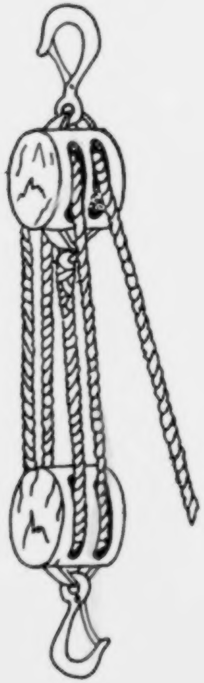
Types Of Tackles



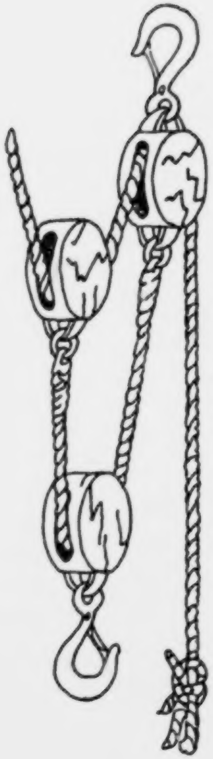
Single Whip Tackle



Gun Tackle



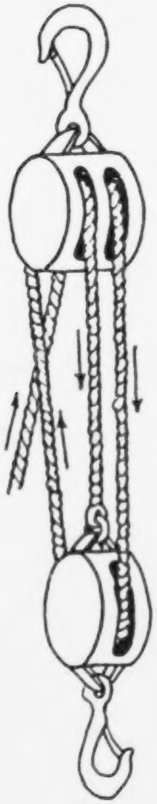
Simple Tackle



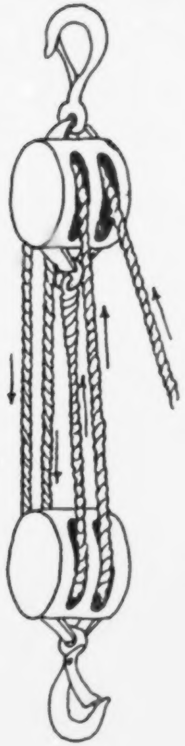
Compound Tackle

Types Of Tackles

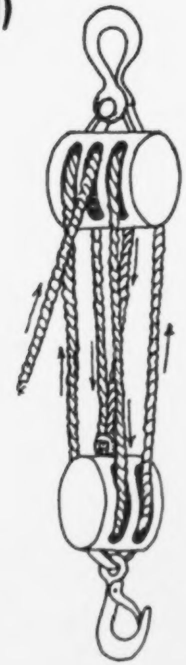
(Continued)



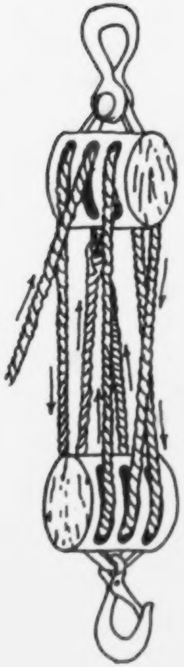
Single Luff



Twofold Purchase



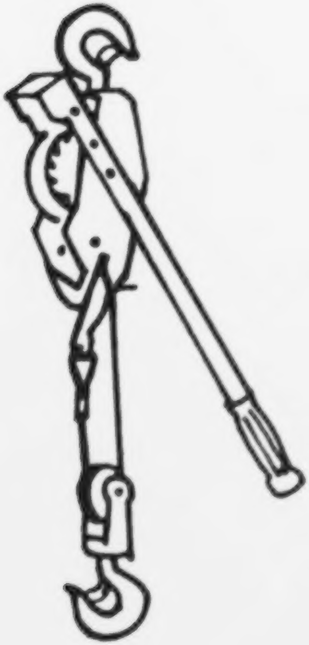
Double Luff



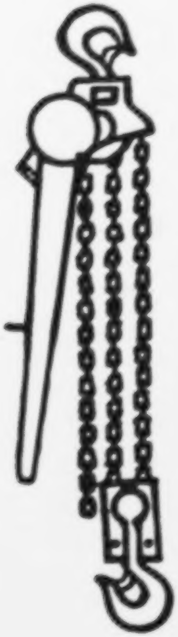
Threefold Purchase

Types Of Come-a-longs

(Portable Winches)

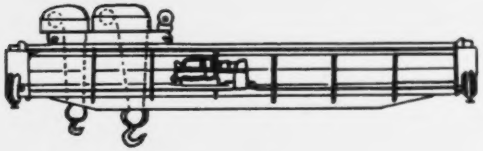


Cable

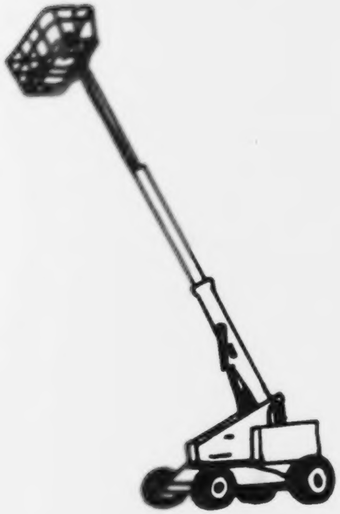


Chain

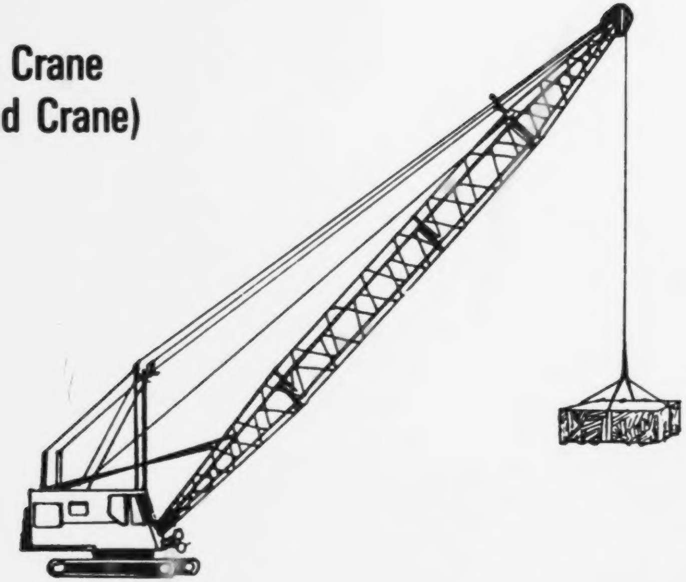
Types Of Hoists



Bridge Crane
(Overhead Crane)



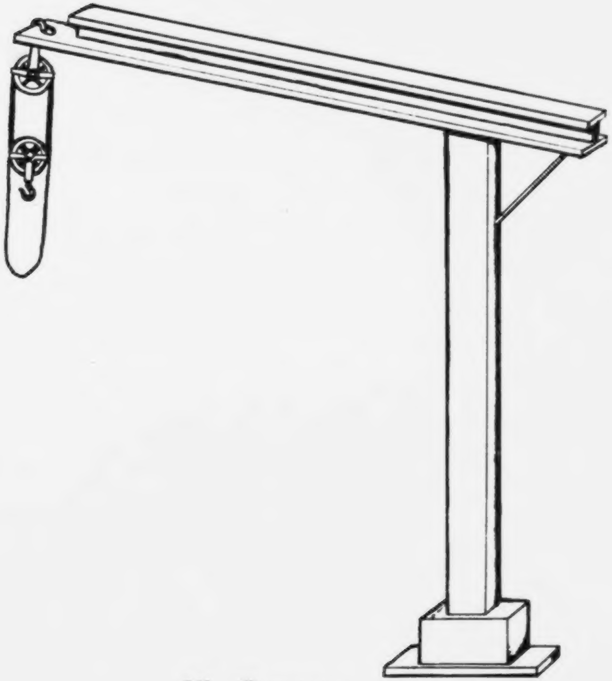
Cherry Picker
or Personnel Lift



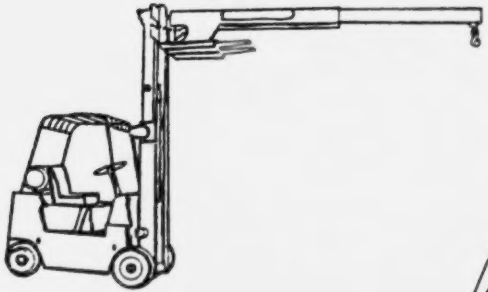
Crane

Types Of Hoists

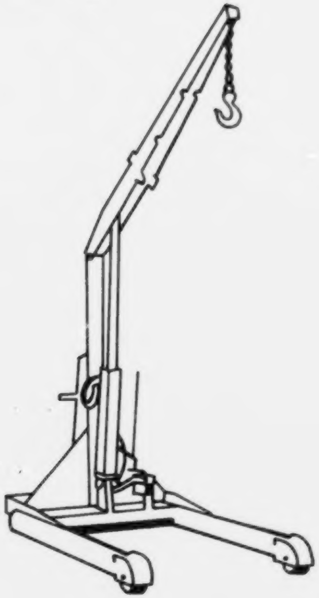
(Continued)



Jib Crane

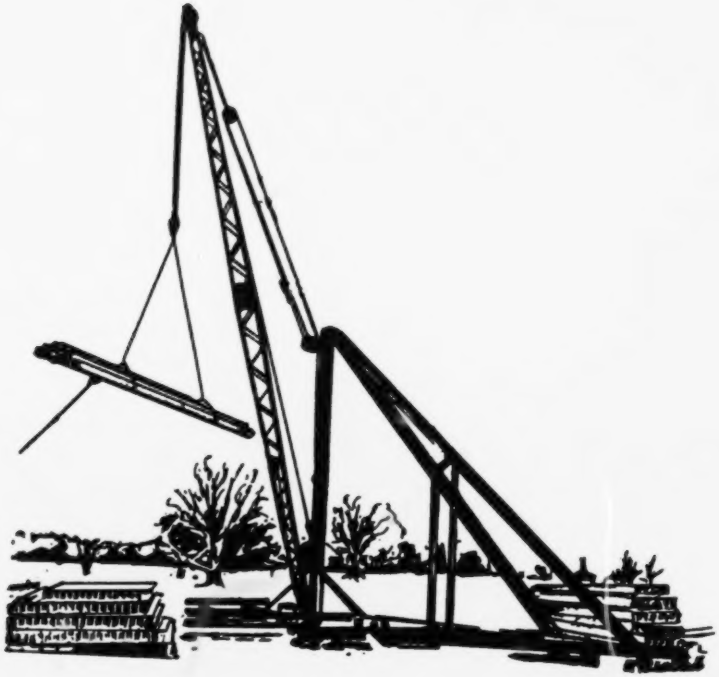


Forklift

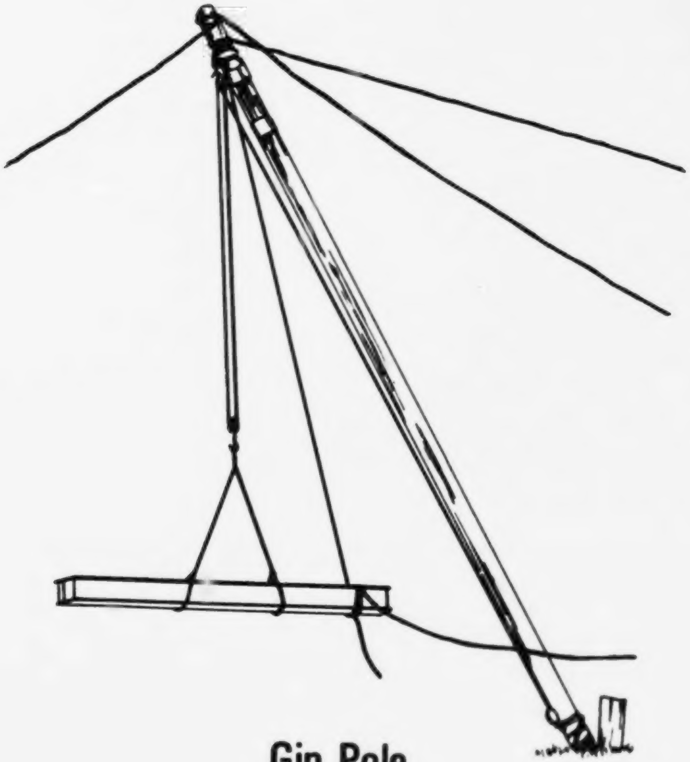


Floor Cranes

Types Of Hoists
(Continued)



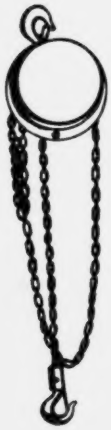
Stiff Leg Derrick



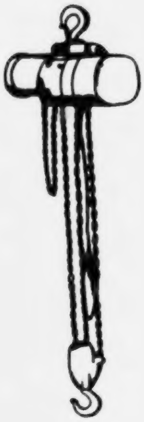
Gin Pole

Types Of Hoists

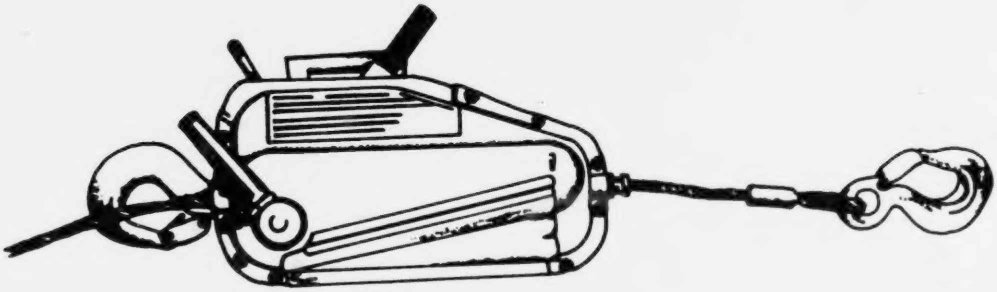
(Continued)



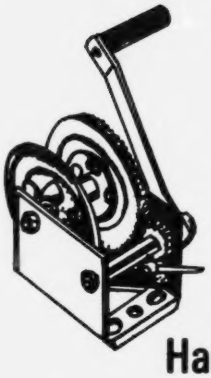
Chain Hoist (Hand)



Chain Hoist (Electric)

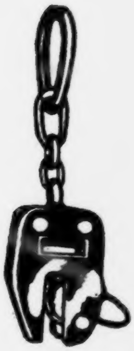


Grip Hoist

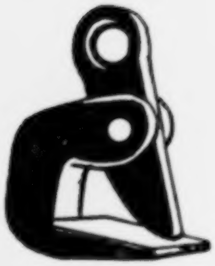


Hand Winch

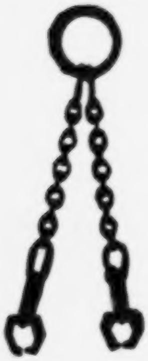
Lifting Devices



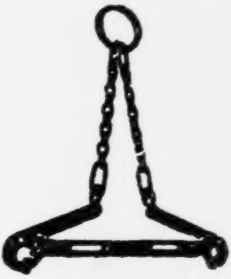
Vertical Plate Clamp



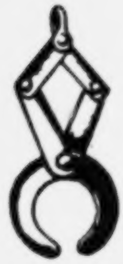
Horizontal Plate Clamp



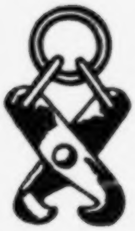
Drum Grip



Vertical Drum Grip



Pipe Tong



Beam Tong

RIGGING AND HOISTING
UNIT I

ASSIGNMENT SHEET #1--CALCULATE SAFE WORKING LOAD OF ROPES

Calculate the working load of the following ropes, using a safety factor of 5.

1. One-half inch polypropylene rope with 4,500 pounds tensile strength safe working load.

   ____

2. One-inch nylon rope with 24,000 pounds tensile strength safe working load.

   ____

3. Three-quarter inch dacron rope with 10,000 pounds tensile strength safe working load.

   ____

RIGGING AND HOISTING
UNIT I

ANSWERS TO ASSIGNMENT SHEET

1. 4,500÷5 = 900
2. 24,000÷5 = 4,800
3. 10,000÷5 = 2,000

RIGGING AND HOISTING
UNIT I

TEST

NAME ________________________________ SCORE ______________

1. Match terms associated with rigging and hoisting to the correct definitions. Place the correct numbers in the blanks provided.

_____a. To set the brakes

_____b. Term used in relation to stacking and hoisting material and equipment

_____c. Ways of fastening slings or chokers to a load

_____d. Short piece of rope, cable, or chain with an eye on each end or an eye on one end and a hook on the other

_____e. Two-legged sling which supports the load at two or more points or two or more chokers fastened to a common ring

_____f. Sections of rope, cable, belt, or chain fastened together to form a continuous loop

_____g. Rope used to guide or steady loads

_____h. Hook with a safety latch

_____i. One or more sheaves fitted in a frame supported by a hook or shackle inserted in the strap of the block

_____j. Assembly of blocks and lines used to gain a mechanical advantage in lifting

_____k. Device used for pulling and/or stretching wire, cable, or rope; often used to secure loads of material

_____l. Long bar designed for large loads; connected from lifting device in the center of bar and has holes or brackets where several attachments can be made to distribute the load evenly

1. Block
2. Rigging
3. Dog off
4. Come-a-long
5. Choker
6. Sling
7. Safety latch hook
8. Tackle
9. Hitches
10. Tag line
11. Bridle
12. Spreader bar

______m. Single pole with guy lines attached at top and secured to an anchor

______n. Ropes, chains, or cables attached to an object to steady, guide, or secure it

______o. Supplemental hoisting unit with motor, coupling, brakes, gears, drum, ropes, or cables and block to handle lighter loads at faster speeds than provided for main hoist

______p. Device to retard or stop motion by means of friction or power

______q. That part of crane consisting of girders, railings, shafting, walk, drive, and trucks which carries the trolley and travels in a direction parallel to the runway rails

______r. Horizontal travel of crane parallel to runway rails

______s. Energy-absorbing device for reducing impact when a moving crane or trolley reaches the end of its travel

______t. Piece of equipment designed to raise and/or lower heavy loads

______u. Up and down movement of a crane or hoist

______v. Maximum safe vertical distance through which the hook can travel

______w. Compartment from which operator handles the controls

______x. Maximum load which a hoist or crane is designed and built to carry

______y. Unit consisting of frame, trucks, trolley drive, and hoisting mechanism moving on the rails in a direction at right angles to the crane runway

13. Bumper
14. Bridge
15. Hoist
16. Bridge travel
17. Gin pole
18. Brake
19. Auxiliary hoist
20. Lift
21. Trolley
22. Rated load
23. Guy lines
24. Operator's cab
25. Hoist motion

2. Identify the types of hand signals below by placing the correct numbers in the proper blanks. A blank may have more than one answer.

______a. Hoist

______b. Lower

______c. Raise boom

______d. Lower boom

______e. Swing boom

______f. Move slowly

______g. Raise boom and lower load

______h. Lower boom and raise load

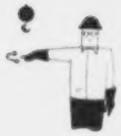
______i. Rack

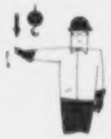
______j. Travel

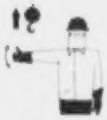
______k. Stop

______l. Dog off load and boom

______m. Emergency stop

1. 

2. 

3. 

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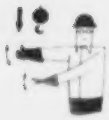
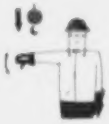
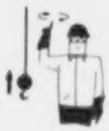
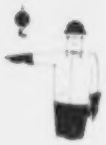
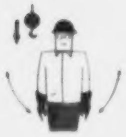
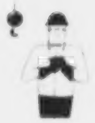
5. 

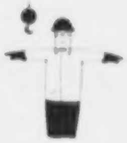
6. 

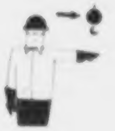
7. 

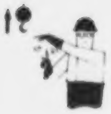
8. 

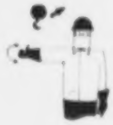
9. 

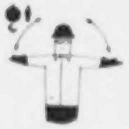
10. 

11. 

12. 

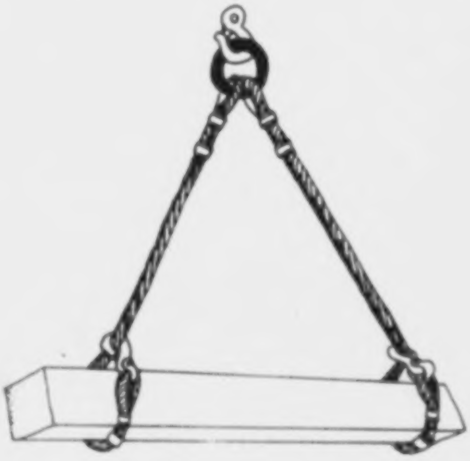
13. 

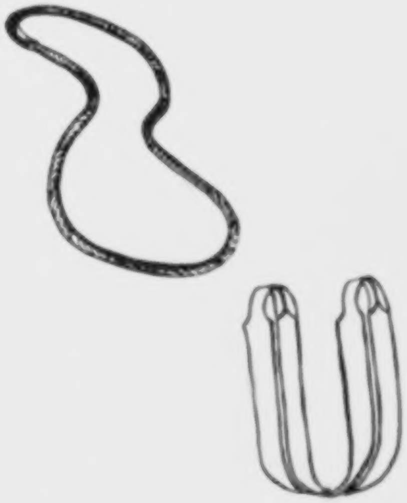
14. 

15. 

16.

3. Identify accessories used for load lifting by writing the correct names under the illustrations.





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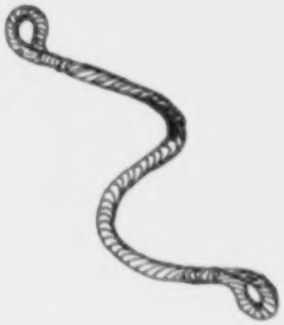

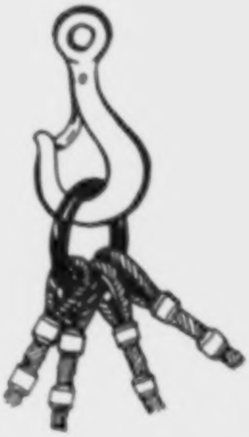

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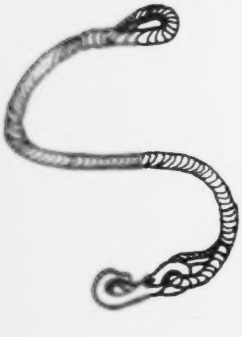
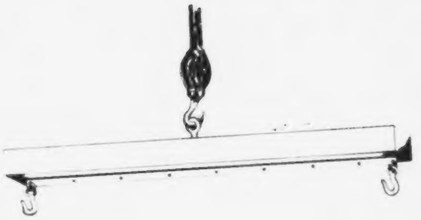
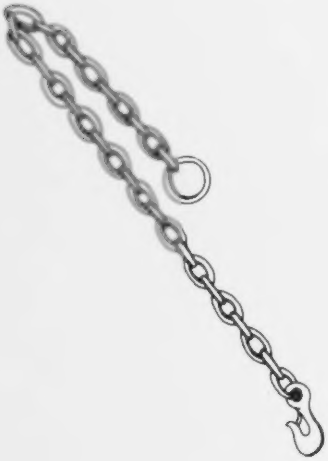


e. ______________________________



f. ______________________________



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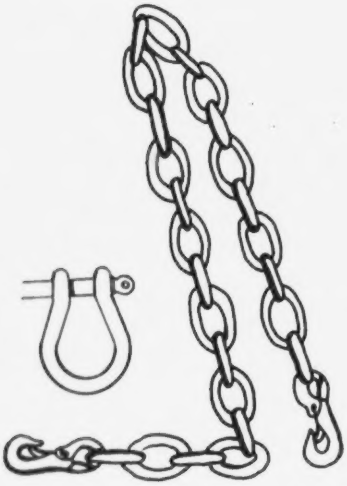
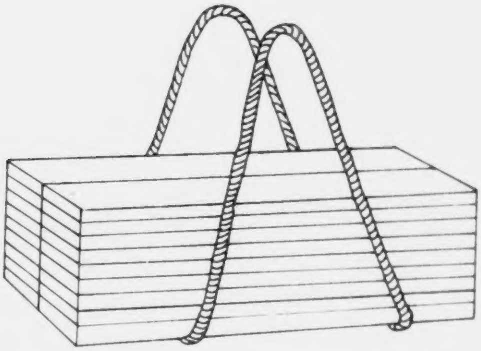
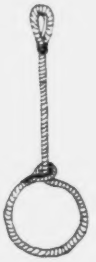


h. ______________________________

4. Identify hitches used for attaching materials and equipment to the hoist. Write the correct names in the blanks provided.





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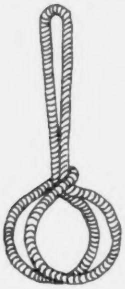
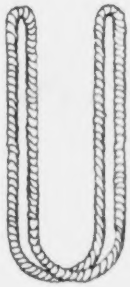
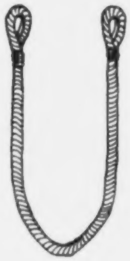
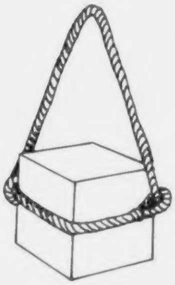




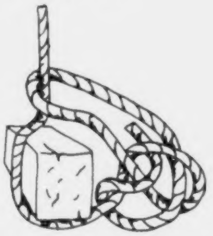
c. ____________________ d. ____________________



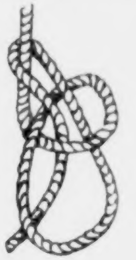


e. ____________________ f. ____________________

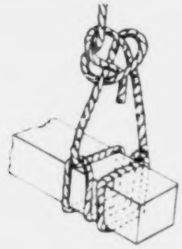
5. Identify the types of knots used in rigging shown below by writing the correct names in the blanks provided.



a. ______________________________



b. ______________________________



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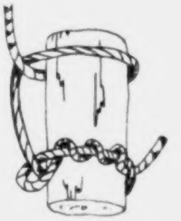
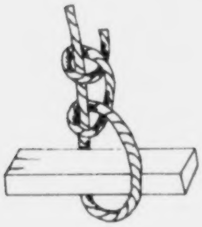


d. ______________________________



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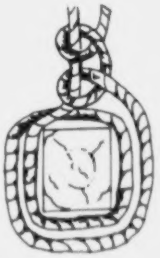

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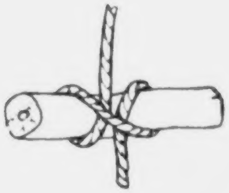

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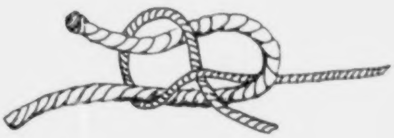
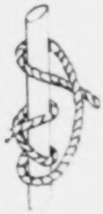
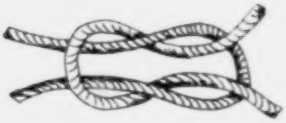


h. ______________________________





i. ______________________ j. ______________________

6. Complete the chart below to determine the tensile strength of various kinds and sizes of new rope.

Diameter	Nylon	Dacron	Polyethylene	Polypropylene	Duraplex
1/2"	6,200	4,400	4,100	4,500	f.____
9/16"	8,000	5,700	5,100	e.____	
5/8"	b.____	7,300	6,000	6,600	
a.____	14,000	10,000	7,500	8,000	14,500
7/8"	19,000	13,600	d.____	10,750	
1"	24,000	c.____	11,000	12,500	31,400
1 1/8"	31,500	21,600	15,000	17,000	
1 1/4"	36,000	24,400	17,300	19,500	

7. Calculate the safe working load of the following ropes.

a. One-half inch nylon with 10,000 pounds tensile strength safe working load and a safety factor of 4.

____

b. One-inch duraplex with 13,400 pounds tensile strength safe working load and a safety factor of 5.

____

c. Three-quarter inch dacron with 10,000 pounds tensile strength safe working load and a safety factor of 5.

____

8. List safety tips related to rigging and hoisting.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

9. Describe a safety latch.

____

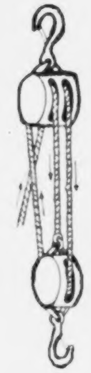
____

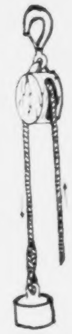
10. Explain spreaders and/or spreader bars.

____

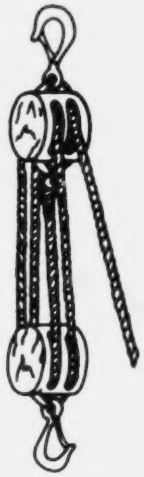
____

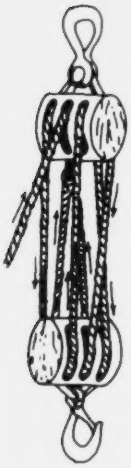
11. Identify the types of tackles illustrated below. Write the correct names in the blanks provided.



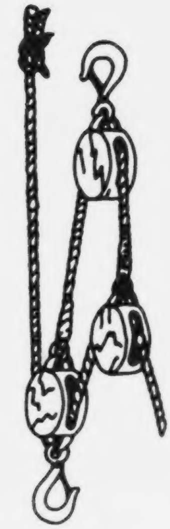


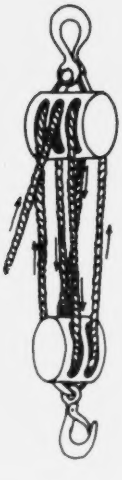
a. ____________________ b. ____________________



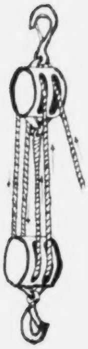


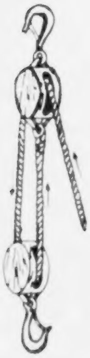
c. ______________________ d. ______________________





e. ______________________ f. ______________________





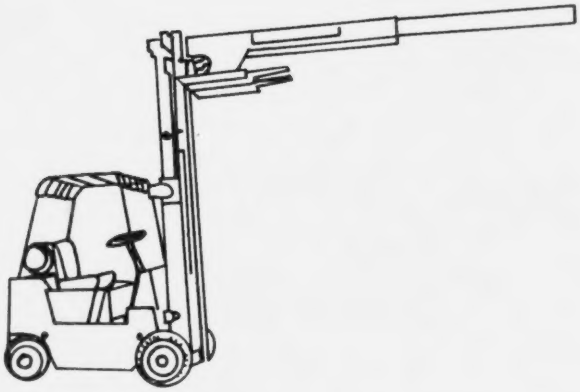
g. ______________________ h. ______________________

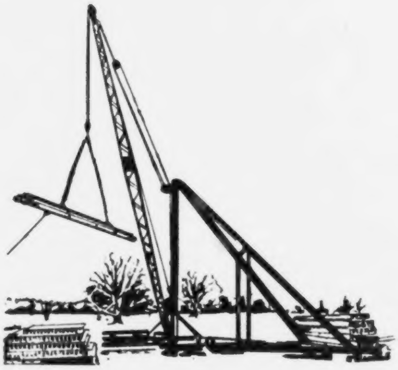
12. List types of come-a-longs (portable winches).

    a. ____

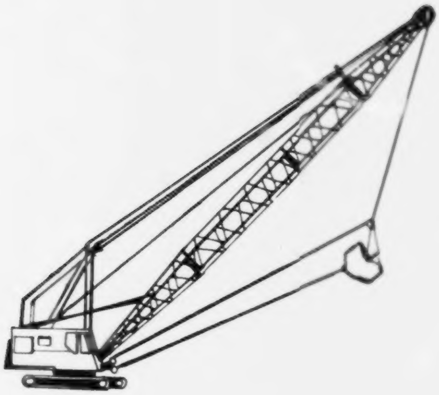
    b. ____

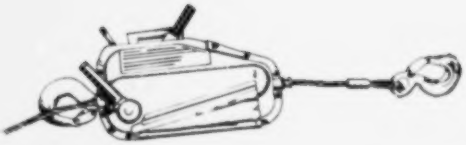
13. Identify types of hoists illustrated below by writing the correct names in the blanks provided.



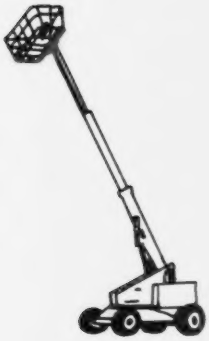


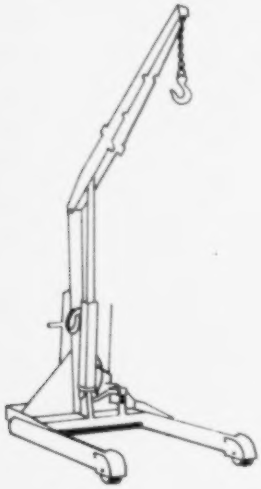
a. ______________________ b. ______________________



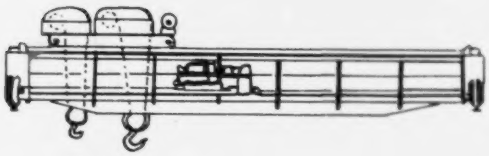


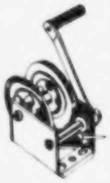
c. ______________________ d. ______________________



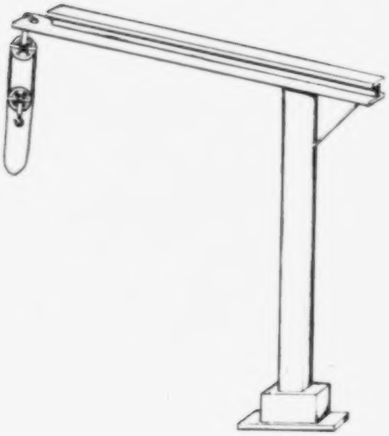


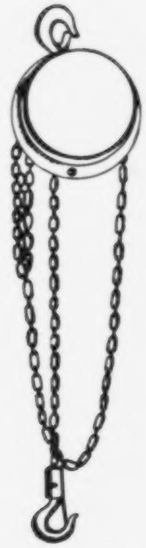
e. ______________________ f. ______________________



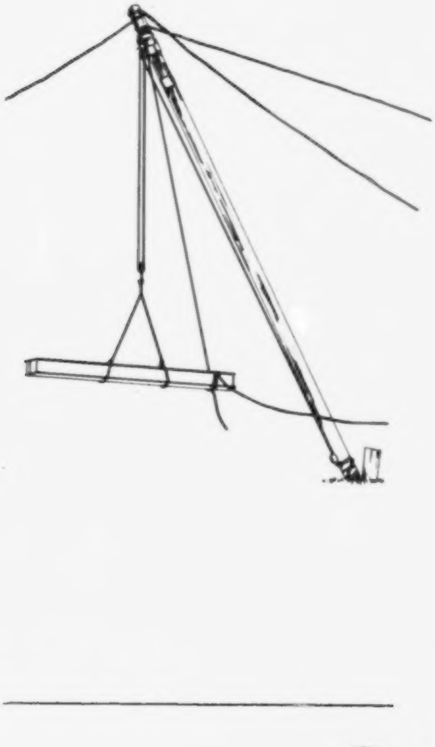


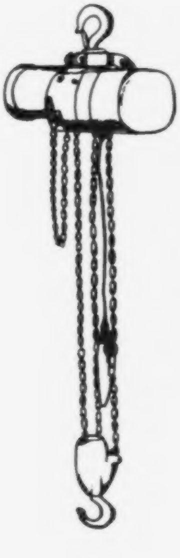
g. ______________________ h. ______________________





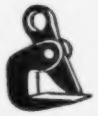
i. ______________________ j. ______________________



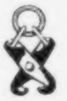


k. ______________________ l. ______________________

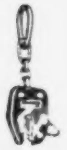
14. Identify the hook lifting devices illustrated below by writing the correct names in the blanks provided.



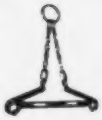
a. ______________



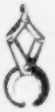
b. ______________



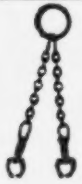
c. ______________



d. ______________



e. ______________



f. ______________

RIGGING AND HOISTING
UNIT I

ANSWERS TO TEST

1. a. 3
   b. 2
   c. 9
   d. 5
   e. 11
   f. 6
   g. 10
   h. 7
   i. 1
   j. 8
   k. 4
   l. 12
   m. 17
   n. 23
   o. 19
   p. 18
   q. 14
   r. 16
   s. 13
   t. 15
   u. 25
   v. 20
   w. 24
   x. 22
   y. 21

2. a. 7, 15
   b. 2, 9
   c. 3
   d. 6
   e. 12
   f. 13
   g. 5
   h. 16
   i. 14
   j. 4
   k. 8, 11
   l. 10
   m. 1

3. a. Bridle
   b. Sling
   c. Choker
   d. Bridle
   e. Choker

f. Spreader bar

g. Bull chain

h. Chain and accessories (shackles)

4. a. Inverted basket hitch

b. Choker hitch

c. Choker hitch

d. Basket hitch

e. Basket hitch

f. Double anchor hitch

5. a. Running bowline

b. Bowline

c. Scaffold hitch

d. Timber hitch and half hitch

e. Two half hitches

f. Round turn and two half hitches

g. Clove hitch

h. Sheet bend

i. Rolling hitch

j. Square knot

6. a. 3/4

b. 10,000

c. 16,500

d. 9,900

e. 5,400

f. 6,700

7. a. 10,000÷4 = 2,500 lbs

b. 13,400÷5 = 2,680 lbs

c. 10,000÷5 = 2,000 lbs

8. a. Use personal protective devices, such as goggles, gloves, safety shoes, and hard hats
   - b. Use tag line to guide and/or steady load
   - c. Do not walk under load
   - d. Be sure load is balanced properly
   - e. Do not overload equipment
   - f. Stand clear when slings are heaved from under loads
   - g. Be extra cautious around power lines
   - h. Make regular, visual checks of all hoisting equipment, including pulleys, ropes, and cables
9. Hook with a latch that keeps load from accidentally being knocked off
10. Devices that are used to prevent crushing of the load and to lift extra long and heavy loads
11. a. Single luff
    - b. Single whip tackle
    - c. Simple tackle
    - d. Threefold purchase
    - e. Compound tackle
    - f. Double luff
    - g. Gun tackle
    - h. Twofold purchase
12. a. Cable
    - b. Chain
13. a. Forklift
    - b. Stiff leg derrick
    - c. Crane
    - d. Grip hoist
    - e. Cherry picker or personnel lift
    - f. Floor crane
    - g. Bridge crane (overhead crane)

- h. Hand winch
- i. Jib cranes
- j. Chain hoist (hand)
- k. Gin pole
- l. Chain hoist (electric)

14. a. Horizontal plate clamp
    b. Beam tongs
    c. Vertical drum grip
    d. Vertical plate clamp
    e. Pipe tongs
    f. Drum grip

UNLOADING, UNCRATING, AND INSPECTION
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to list steps to take to prevent damage when unloading equipment and arrange in order steps to take after unloading equipment. The student should also be able to select from a list items to look for when receiving equipment. This knowledge will be evidenced by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Define terms associated with unloading, uncrating, and inspection.
2. List steps to take to prevent damage when unloading equipment.
3. Arrange in order steps to take after equipment has been unloaded.
4. Select from a list items to look for when receiving equipment.

UNLOADING, UNCRATING, AND INSPECTION
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information sheet.

  C. Discuss unit and specific objectives.

  D. Discuss information sheet.

  E. Give test.

II. Instructional materials:

  A. Objective sheet

  B. Information sheet

  C. Test

  D. Answers to test

UNLOADING, UNCRATING, AND INSPECTION
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Borings or cuttings--Shavings or scrapes left from boring or tapping holes

   B. Inspect--To examine

   C. Rust inhibitor--Compound used to coat metal parts to prevent rust

   D. Journal--That part of a rotating shaft, axle, roll, or spindle that turns in a bearing

II. Steps to take to prevent damage when unloading equipment

   A. Use proper lifting equipment

   B. Secure equipment safely

   C. Do not handle equipment roughly

   D. Use lifting lugs and/or eyebolts provided by manufacturer

III. Steps to take after equipment has been unloaded

   A. Remove bracing from crate

   B. Pull nails and remove crating from skids

   C. Remove any wrapping or packing from equipment

   D. Clean any antirust or corrosion compounds from equipment

   E. Visually inspect equipment

   F. Move equipment to its permanent location

   G. Give equipment more thorough inspection after equipment has been moved to its permanent location

IV. Items to look for when receiving equipment

   (NOTE: If equipment is to be idle or in storage for a period of time before operation, all machined parts should be recoated with a good rust-inhibitor.)

   A. Check to see that all parts were delivered

   B. Check for any missing parts

INFORMATION SHEET

C. Check for any broken parts

D. Check to see that all parts fit (line shafts, connectors, pulleys)

E. Check to see that no borings, cuttings, or other foreign materials have been left inside equipment

F. Rotate all equipment at least every thirty days to protect bearings and journals from rust

(NOTE: All of these items should be checked prior to signing the acceptance slip.)

UNLOADING, UNCRATING, AND INSPECTION
UNIT II

TEST

NAME ______________________________ SCORE ____________________

1. Define the following terms associated with unloading, uncrating, and inspection.

   a. Borings or cuttings--______________________________

   ____

   b. Inspect--______________________________

   c. Rust inhibitor--______________________________

   ____

   d. Journal--______________________________

   ____

2. List steps to take to prevent damage when unloading equipment.

   a. ______________________________

   b. ______________________________

   c. ______________________________

   d. ______________________________

3. Arrange in order steps to take after equipment has been unloaded. Place a "1" in front of the first step, a "2" in front of the second, and so on.

   ______a. Remove bracing from crate

   ______b. Move equipment to its permanent location

   ______c. Remove any wrapping or packing from equipment

   ______d. Give equipment more thorough inspection after equipment has been moved to a permanent location

   ______e. Pull nails and remove crating from skids

   ______f. Visually inspect equipment

   ______g. Clean any antirust or corrosion compounds from equipment

4. Select from the list below items to look for when receiving equipment. Place an "X" in the appropriate blanks.

   ______a. Check to see that all parts were delivered

   ______b. Rotate all equipment at least every sixty days to protect bearings and journals from rust

   ______c. Check for any broken parts

   ______d. Check to see that all parts fit (line shafts, connectors, pulleys)

   ______e. Check to see that no borings, cuttings, or other foreign materials have been left inside equipment

   ______f. Check to see that there are no blown fuses

UNLOADING, UNCRATING, AND INSPECTION
UNIT II

ANSWERS TO TEST

1. a. Shavings or scrapes left from boring or tapping holes
   b. To examine
   c. Compound used to coat metal parts to prevent rust
   d. That part of a rotating shaft, axle, roll, or spindle that turns in a bearing
2. a. Use proper lifting equipment
   b. Secure equipment safely
   c. Do not handle equipment roughly
   d. Use lifting lugs and/or eyebolts provided by manufacturer
3. a. 1
   b. 6
   c. 3
   d. 7
   e. 2
   f. 5
   g. 4
4. a, c, d, e

SETTING EQUIPMENT
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to explain where to find installation location for machinery and equipment and when equipment is secured with anchor bolts or with bedplates. The student should be able to list vibration and noise control materials, identify types of machine mounts, and explain the purpose of machine mounts. The student should also be able to use a formula to level equipment and set a pump using shims and wedges prior to grouting. This knowledge will be evidenced by completion of the assignment sheet, job sheet, and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with setting equipment to the proper definitions.
2. Explain installation location for machinery and equipment.
3. Distinguish between uses of anchor bolts and bedplates when securing equipment.
4. List vibration and noise control materials.
5. Identify types of machine mounts.
6. Explain the purpose of machine mounts.
7. Explain what is usually the most important operation in machinery installation.
8. Describe the formula used to level equipment.
9. Identify the most common method of setting foundation bolts.
10. Explain why sleeves are used around anchor bolts.
11. Use a formula to level equipment.
12. Demonstrate the ability to set a pump using shims and wedges prior to grouting.

SETTING EQUIPMENT
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information, assignment, and job sheet.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information and assignment sheets.

  F. Demonstrate and discuss procedures outlined in job sheet.

  G. Give test.

II. Instructional materials:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Equipment Foundation Layout

    2. TM 2--Types of Machinery Mounts

  D. Assignment Sheet #1--Use a Formula to Level Equipment

  E. Answers to assignment sheet

  F. Job Sheet #1--Set a Pump Using Shims and Wedges Prior to Grouting

  G. Test

  H. Answers to test

III. Unit reference--Nelson, Carl A. *Millwright's and Mechanic's Guide.* 2nd ed. Indianapolis, Indiana: Howard W. Sams and Co., Inc., 1978.

SETTING EQUIPMENT
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Bedplate--Type of machinery mount which is leveled and fastened to the foundation prior to mounting the equipment

   B. Fastener--Type of anchor used to secure the machinery

   C. Foundation--Base upon which the equipment rests

   D. Anchor bolt--Bolt set into the foundation on which the equipment or bedplates are anchored

   E. Grout--Mixture of cement, sand, and water mixed fluid enough to run under bedplate and/or equipment

   (NOTE: There are many types of commercial grouts; check specifications.)

   F. Shim--Thin, often tapered piece of material used for support, leveling, or adjustment

   G. Downtime--Length of time equipment and machinery are shut down for repairs and/or replacement

   H. Damping--To absorb sound and vibration

   I. Alignment--To properly position or adjust equipment

   J. Template--Gage, pattern, or mold used as a guide

   K. Sleeve--Piece of tin, pipe, or other material used to create a space between anchor bolts and concrete foundation

   L. Jack bolt--Used to raise and/or adjust equipment to elevation

   (NOTE: Used along with anchor bolt.)

II. Installation locations for machinery and equipment--Plans and drawings are usually available to show locations of equipment; these drawings usually make reference to points or surfaces such as walls, building columns, or other machinery or equipment (Transparency 1)

III. Uses of anchor bolts and bedplates when securing equipment

   A. Anchor bolts--Used to secure equipment to foundation

   B. Bedplates--Used when very accurate alignment is needed or when two or more units require alignment

INFORMATION SHEET

IV. Vibration and noise control materials

A. Felt padding

B. Cork

C. Rubber

D. Machine mounts

(NOTE: There are many different types of vibration and noise control materials used for specific installations.)

V. Types of machine mounts (Transparency 2)

A. Spring mount for light to medium weight machinery

B. Spring mount with built-in damping features

C. Wedge-type leveling mount

D. Special leveling mount used for heavy and high-impact or severe vibration machinery

VI. Purpose of machine mounts--Designed to control shock, vibration, noise, and internal stress in the machine and to secure the machine or equipment to its foundation

(NOTE: Machine should be checked periodically for alignment when using these type mounts.)

VII. Usually the most important operation in machinery installation--Leveling and aligning the equipment

VIII. Formula used to level equipment (Assignment Sheet #1)

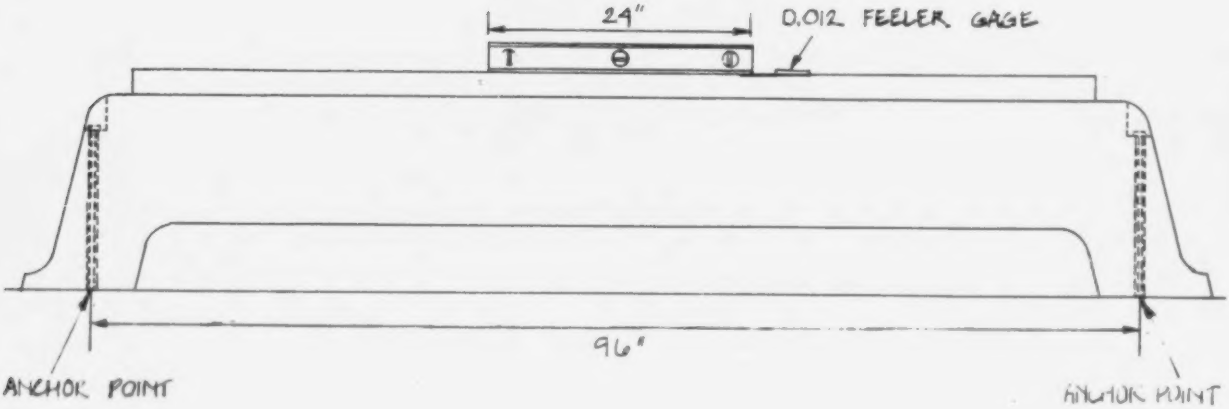
A. Use a feeler gage under low end of level and determine the amount of off-level by centering the level

B. Determine the approximate ratio of the level length to the distance between shimming points

INFORMATION SHEET

C. Thickness of the shims will be the ratio times the measurement of the feeler gage

Example:

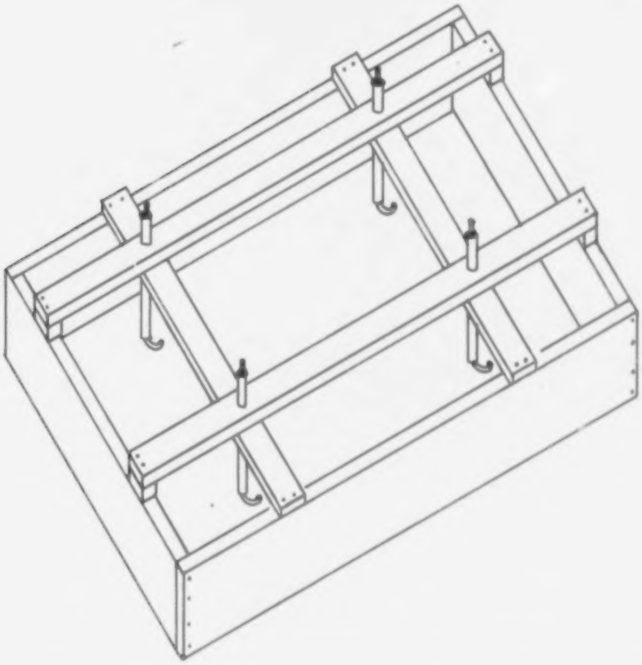

24"
0.012 FEELER GAGE
96"
ANCHOR POINT
ANCHOR POINT

24" level with a 0.012 feeler gage under low end centers bubble. Distance between bearing points is 96" or 4 times the length of level; the shim required is 4 x 0.012 or 0.048" thick

INFORMATION SHEET

IX. Most common method of setting foundation bolts

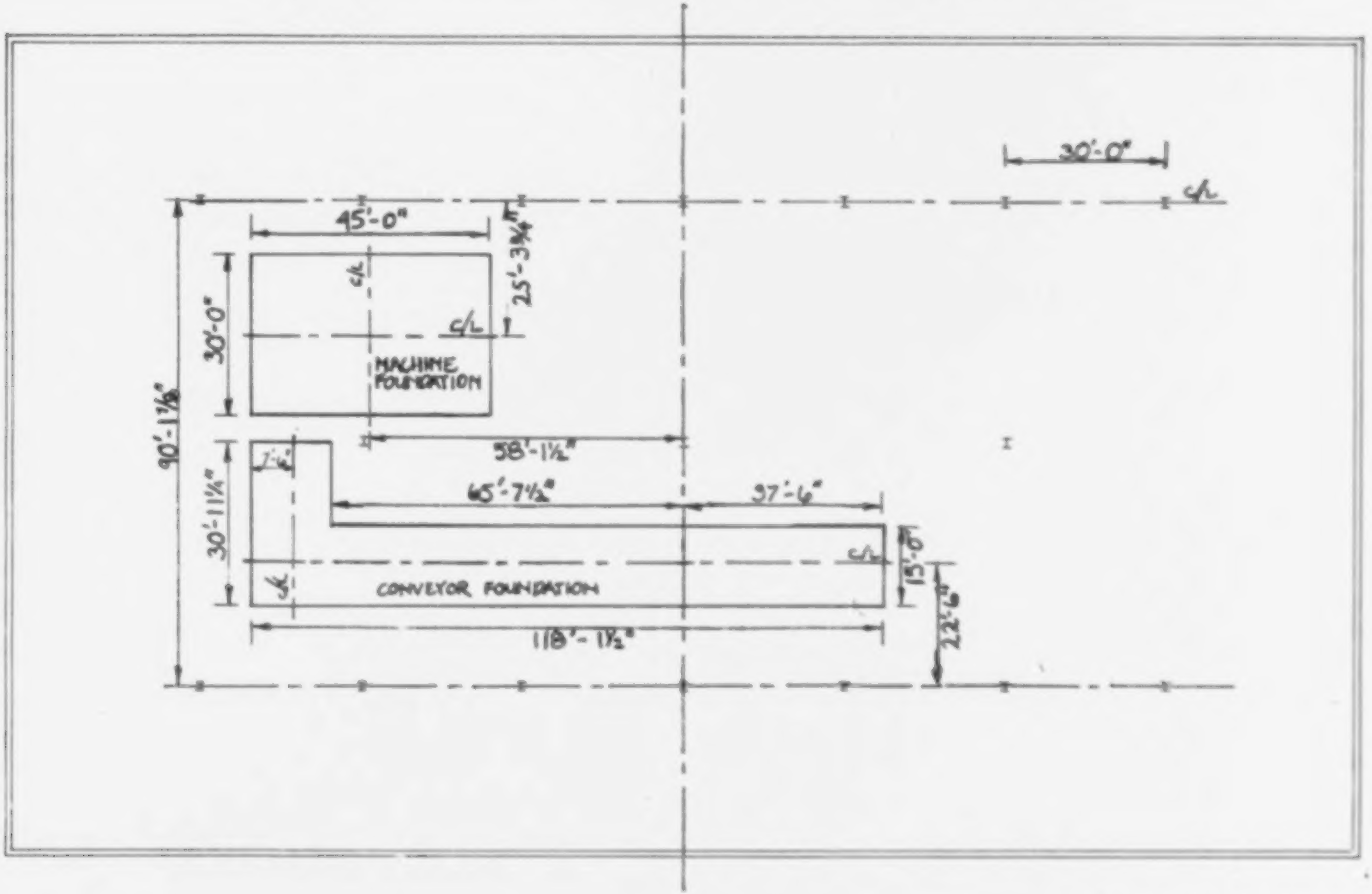
(NOTE: Use a wood template with holes corresponding to those in the machine. Nail template to form and suspend sleeves centrally from each hole. Sometimes with heavy machinery it is necessary to secure the bottom part of the bolt to channels or angle irons.)



X. Why sleeves are used around anchor bolts--Sleeves should be larger than the bolt diameter so that there can be a lateral adjustment

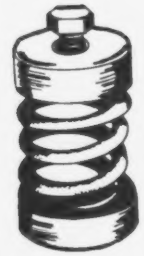
(CAUTION: Sleeves should be protected so that they are not filled with concrete, dirt, or debris and must be cleaned out before installing equipment.)

Equipment Foundation Layout

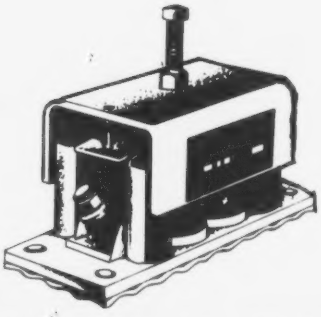

30'-0"
c/L
45'-0"
25'-3¾"
c/L
c/L
30'-0"
MACHINE FOUNDATION
90'-1⅞"
58'-1½"
7'-6"
30'-11¼"
65'-7½"
37'-6"
c/L
15'-0"
c/L
22'-6"
CONVEYOR FOUNDATION
118'-1½"

SCALE: 1" = 30'-0"

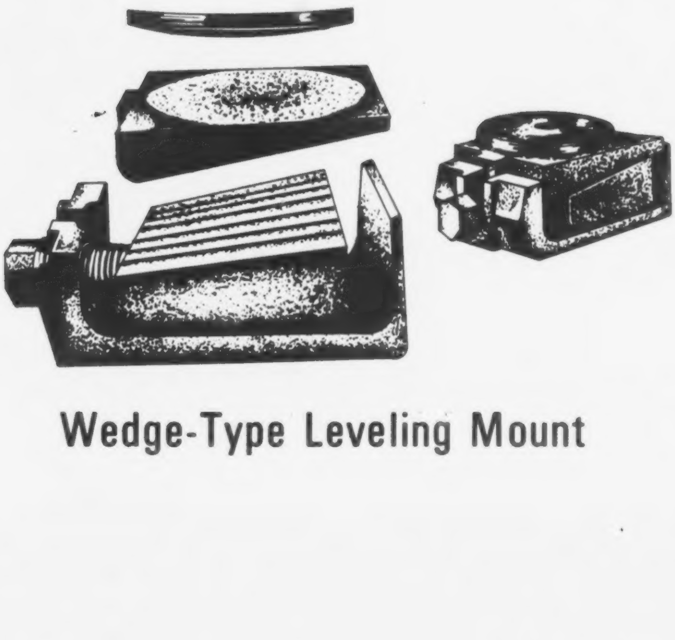
Types of Machinery Mounts



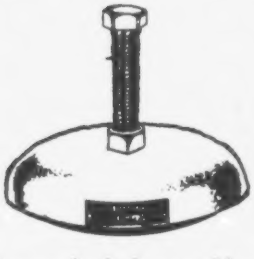
Spring Mount for Light to Medium Weight Machinery



Spring Mount with Built-In Damping Features



Wedge-Type Leveling Mount



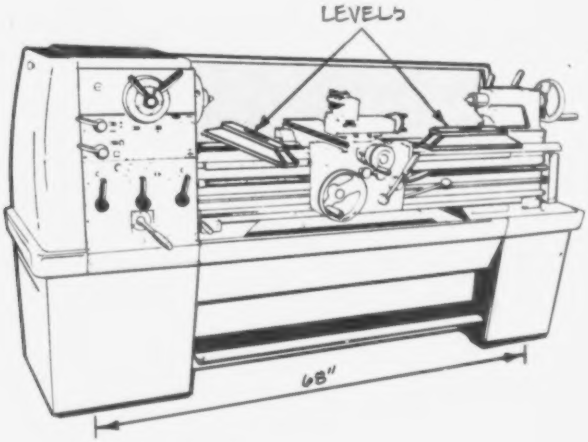
Special Leveling Mount Used for Heavy and High-Impact or Severe Vibration Machinery

SETTING EQUIPMENT
UNIT III

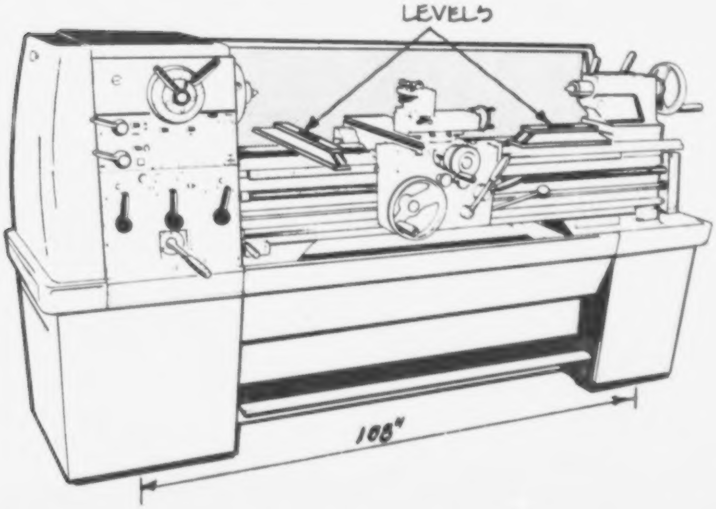
ASSIGNMENT SHEET #1--USE A FORMULA TO LEVEL EQUIPMENT

Level the pieces of equipment below and on next page using the correct formula.

(NOTE: Be sure equipment is level in both directions.)

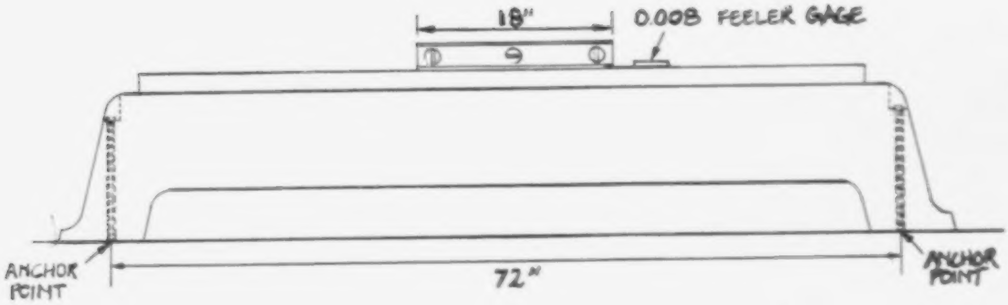


1. ______________________________

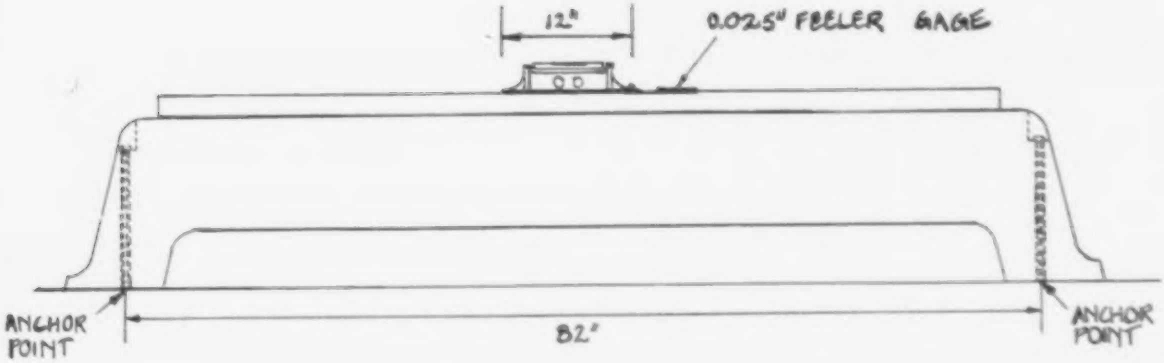


2. ______________________________

ASSIGNMENT SHEET #1


18"
0.008 FEELER GAGE
ANCHOR POINT
72"
ANCHOR POINT

3. ______________________________


12"
0.025" FEELER GAGE
ANCHOR POINT
82"
ANCHOR POINT

4. ______________________________

SETTING EQUIPMENT
UNIT III

ANSWERS TO ASSIGNMENT SHEET

1. 0.180
2. 0.090
3. 0.032
4. 0.175

SETTING EQUIPMENT
UNIT III

JOB SHEET #1--SET A PUMP USING SHIMS AND WEDGES PRIOR TO GROUTING

I. Tools and materials

A. Precision level

B. Metal shims and wedges

C. Indicator and holder

D. Assorted wrenches

E. Blueprints

II. Procedure

A. Make a preliminary check of motor and pump for alignment

B. Prepare (clean) foundation and anchor bolts prior to installation

(NOTE: Never use anchor bolts as jack bolts.)

C. Set unit on foundation anchor bolts

D. Use dimensions from blueprints to center intake and reach proper elevation for discharge

E. Level pump by plumbing the intake and discharge flanges of pump

(NOTE: Refer to blueprints for pump elevation.)

F. Place shims and/or wedges between bedplate and concrete and raise or lower until unit is level

G. Tighten down anchor bolts

H. Recheck alignment

(NOTE: Check coupling alignment after unit has been leveled and placed on center lines. Be sure pump is secured to base plate.)

I. Grout pump

J. Make final alignment of motor to pump

SETTING EQUIPMENT
UNIT III

TEST

NAME ____ SCORE ____________

1. Match terms associated with setting equipment to the correct definitions by placing the correct numbers in the blanks provided.

______ a. Type of machinery mount which is leveled and fastened to the foundation prior to mounting the equipment

______ b. Type of anchor used to secure the machinery

______ c. Base upon which the equipment rests

______ d. Bolt set into the foundation on which the equipment or bedplates are anchored

______ e. Mixture of cement, sand, and water mixed fluid enough to run under bedplate and/or equipment

______ f. Thin, often tapered piece of material used for support, leveling, or adjustment

______ g. Length of time equipment and machinery are shut down for repairs and/or replacement

______ h. To absorb sound and vibration

______ i. To properly position or adjust equipment

______ j. Gage, pattern, or mold used as a guide

______ k. Piece of tin, pipe, or other material used to create a space between anchor bolts and concrete foundation

______ l. Used to raise and/or adjust equipment to elevation

1. Damping
2. Downtime
3. Grout
4. Sleeve
5. Bedplate
6. Foundation
7. Template
8. Fastener
9. Anchor bolt
10. Shim
11. Alignment
12. Jack bolt

2. Explain installation locations for machinery and equipment.

____

____

____

____

3. Distinguish between uses of anchor bolts and bedplates when securing equipment. Place an "X" in the blank before the correct use of the anchor bolt.

   ______a. Used when very accurate alignment is needed or when two or more units require alignment

   ______b. Used to secure equipment to foundation

4. List four vibration and noise control materials.

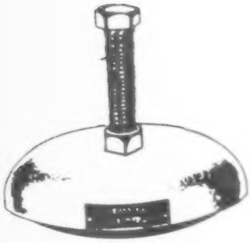
   a. ______________________________

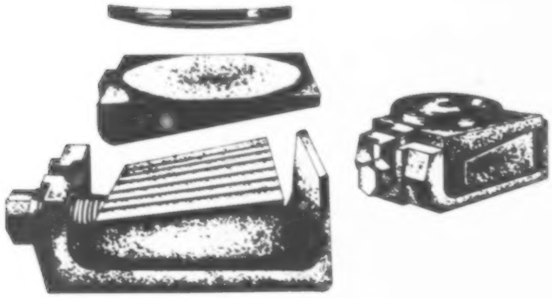
   b. ______________________________

   c. ______________________________

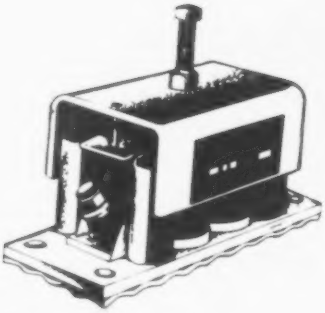
   d. ______________________________

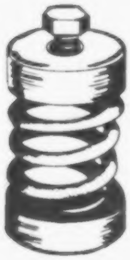
5. Identify the types of machine mounts in the following illustrations. Place the correct names in the blanks provided.





a. ______________________ b. ______________________





c. ______________________ d. ______________________

6. Explain the purpose of machine mounts.

7. Explain what is usually the most important operation in machinery installations.

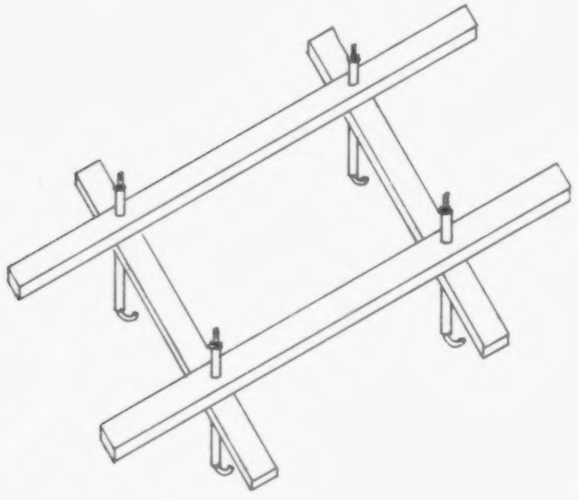
8. Describe the formula used to level equipment.

   a. ______________________

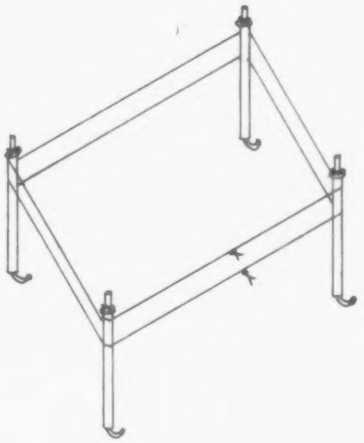
   b. ______________________

   c. ______________________

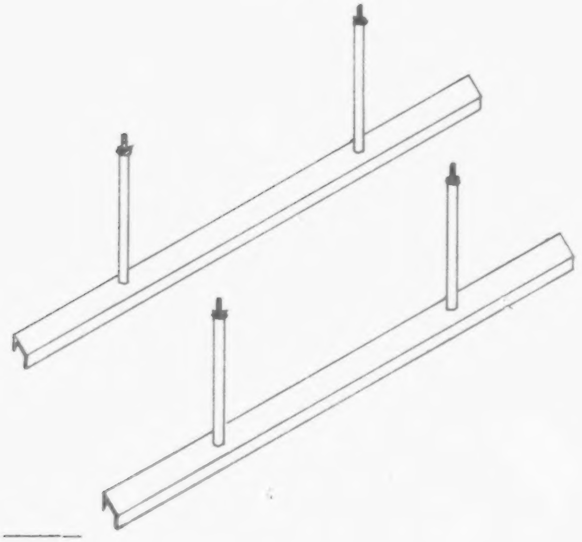
9. Identify the most common method of setting foundation bolts by placing an "X" in the correct blank.



a. ____



b. ____



c. ____

10. Explain why sleeves are used around anchor bolts.

____

____

11. Use a formula to level equipment.

12. Demonstrate the ability to set a pump using shims and wedges prior to grouting.

SETTING EQUIPMENT
UNIT III

ANSWERS TO TEST

1. a. 5
   b. 8
   c. 6
   d. 9
   e. 3
   f. 10
   g. 2
   h. 1
   i. 11
   j. 7
   k. 4
   l. 12

2. Plans and drawings are usually available to show locations of equipment; these drawings usually make reference to points or surfaces such as walls, building columns, or other machinery or equipment

3. b

4. a. Felt padding
   b. Cork
   c. Rubber
   d. Machine mounts

5. a. Special leveling mount used for heavy and high-impact or severe vibration machinery
   b. Wedge-type leveling mounts
   c. Spring mount with built-in damping features
   d. Spring mount for light to medium weight machinery

6. Designed to control shock, vibration, noise, and internal stress in the machine and to secure the machine or equipment to its foundations

7. Leveling and aligning the equipment

8. a. Use a feeler gage under low end of level and determine the amount of off-level by centering the level

   b. Determine the approximate ratio of the level length to the distance between shimming points

   c. Thickness of the shims will be the ratio times the measurement of the feeler gage

9. a

10. Sleeves should be larger than the bolt diameter so there can be a lateral adjustment

11. Evaluated to the satisfaction of the instructor

12. Performance skills evaluated to the satisfaction of the instructor

MILLWRIGHT INSTRUCTIONAL MATERIALS
PROGRESS CHART

Section G
Receiving and Setting Equipment

	UNIT I RIGGING & HOISTING					UNIT II UNLOADING, UNCRATING, and INSPECTION					UNIT III SETTING EQUIPMENT									
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5					
Job	Unit Test	Calculate Safe Working Load of Rope				Unit Test					Unit Test	Use Formula to Level Equipment	Set Pump Ready for Grout Using Shims and Wedges							
Student's Name																				
1																				
2																				
3																				
4																				
5																				
6																				
7																				

Accuracy	85% Correct	To Satisfaction of Instructor				85% Correct					85% Correct	To Satisfaction of Instructor	To Satisfaction of Instructor							
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				

MILLWRIGHT INSTRUCTIONAL MATERIALS
PROGRESS CHART

Section G
Receiving and Setting Equipment

	UNIT I RIGGING & HOISTING					UNIT II UNLOADING, UNCRATING, and INSPECTION					UNIT III SETTING EQUIPMENT									
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5					
Job	Unit Test	Calculate Safe Working Load of Rope				Unit Test					Unit Test	Use Formula to Level Equipment	Set Pump Ready for Grout Using Shims and Wedges							
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Accuracy	85% Correct	To Satisfaction of Instructor				85% Correct					85% Correct	To Satisfaction of Instructor	To Satisfaction of Instructor							
9																				
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EQUIPMENT ALIGNMENT AND LEVELING
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to set, align and level a piece of equipment. This knowledge will be evidenced by completion of the job sheet and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with alignment and leveling to the correct definitions.
2. Name popular and accurate methods of alignment.
3. Arrange in order procedures to follow when setting and aligning equipment.
4. Establish and draw in center lines and/or offset center lines for equipment.
5. Demonstrate the ability to set, align, and level a piece of equipment.

EQUIPMENT ALIGNMENT AND LEVELING
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined in job sheet.

   G. Give test.

II. Instructional materials:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Center Lines

      2. TM 2--Center Lines (Continued)

   D. Job Sheet #1--Set, Align, and Level a Piece of Equipment

   E. Test

   F. Answers to test

III. Unit reference--Hendrix, Laborn J. "Bud." *Commercial Carpentry.* rev. Stillwater: Oklahoma State Department of Vocational and Technical Education/Curriculum and Instructional Materials Center and Associated General Contractors of America, 1979.

EQUIPMENT ALIGNMENT AND LEVELING
UNIT I

INFORMATION SHEET

I. Terms and definitions

   A. Equipment alignment--Proper positioning of equipment

   B. Equipment leveling--Setting equipment on horizontal plane in all directions

   C. Center lines--Lines that are equal distance from each end and/or each side of equipment

   D. Taut--Tightly drawn, with no give or sag

   E. Floor plugs--Metal plugs (usually brass) set in floor on exact center line dimensions used to set center lines and/or for future reference of center lines

   F. Sole plates--Lower plate on which some equipment is set and leveled

II. Popular and accurate methods of alignment (Transparencies 1 and 2)

   A. Center lines layed out on the floor using instrument

   B. Music wire (piano wire) stretched taut on center lines

   C. Laser beam

III. Procedures to follow when setting and aligning equipment

   A. Prepare (clean) foundation, anchor bolts, and sleeves

   B. Establish center lines

   C. Establish elevations

   D. Check anchor bolts for proper layout and length, and damage

   (NOTE: If threads are damaged it may be necessary to rerun them.)

   E. Set, align, and level sole plates

   F. Set equipment on sole plate

   G. Align equipment with center lines

   (NOTE: In some cases center lines may have to be offset.)

INFORMATION SHEET

H. Level equipment

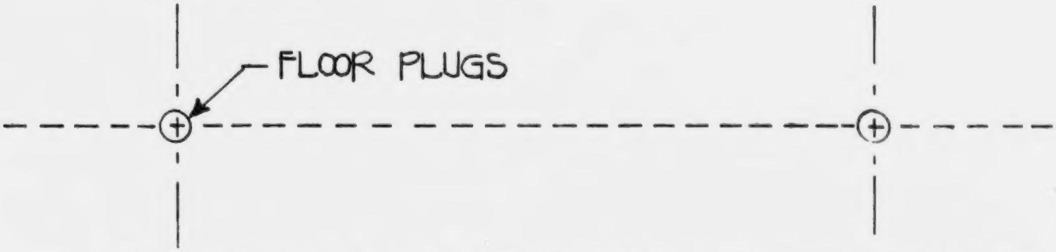
I. Secure equipment

IV. Procedure to follow when laying out a center line

(NOTE: The 3-4-5 method may also be used.)

A. Using floor plugs or markings, stretch a chalk line from one point to corresponding point and snap line

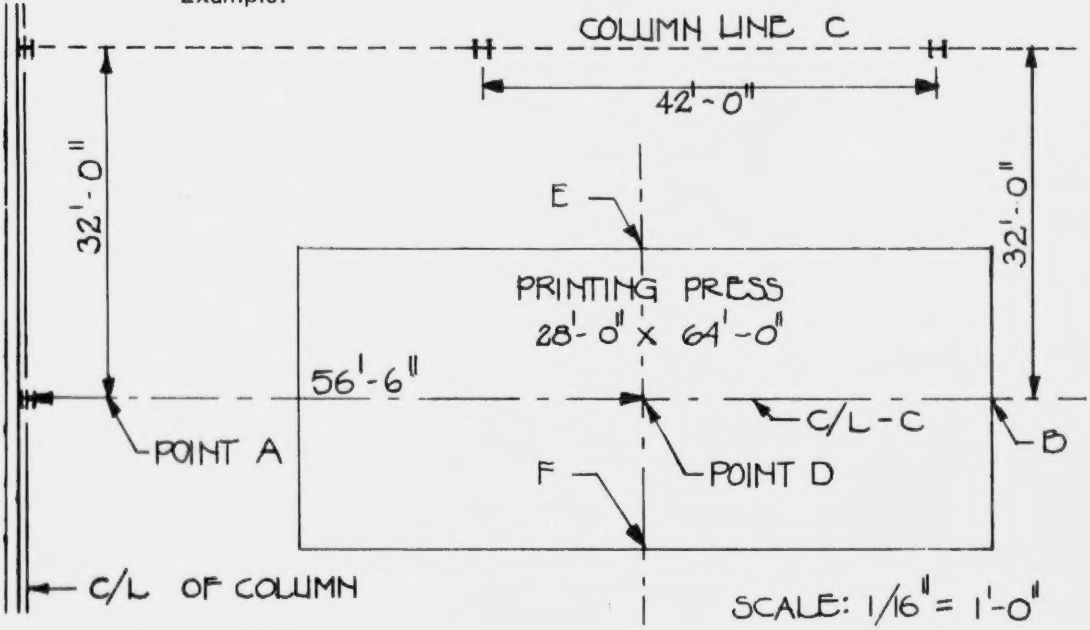
(NOTE: If plugs or points are not already established it will be necessary to check plans.)


FLOOR PLUGS

B. Use dimensions from drawings to establish center lines and true perpendicular lines

(NOTE: Never assume that wall lines and column lines are perfect.)

Example:

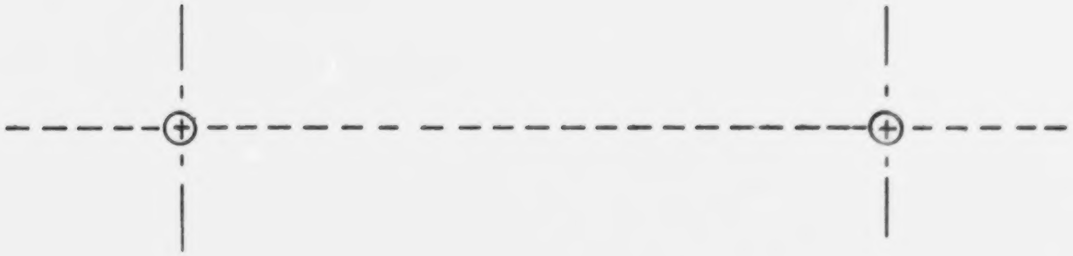

COLUMN LINE C
42'-0"
32'-0"
32'-0"
E
PRINTING PRESS
28'-0" x 64'-0"
56'-6"
C/L-C
B
POINT A
POINT D
F
C/L OF COLUMN
SCALE: 1/16" = 1'-0"

INFORMATION SHEET

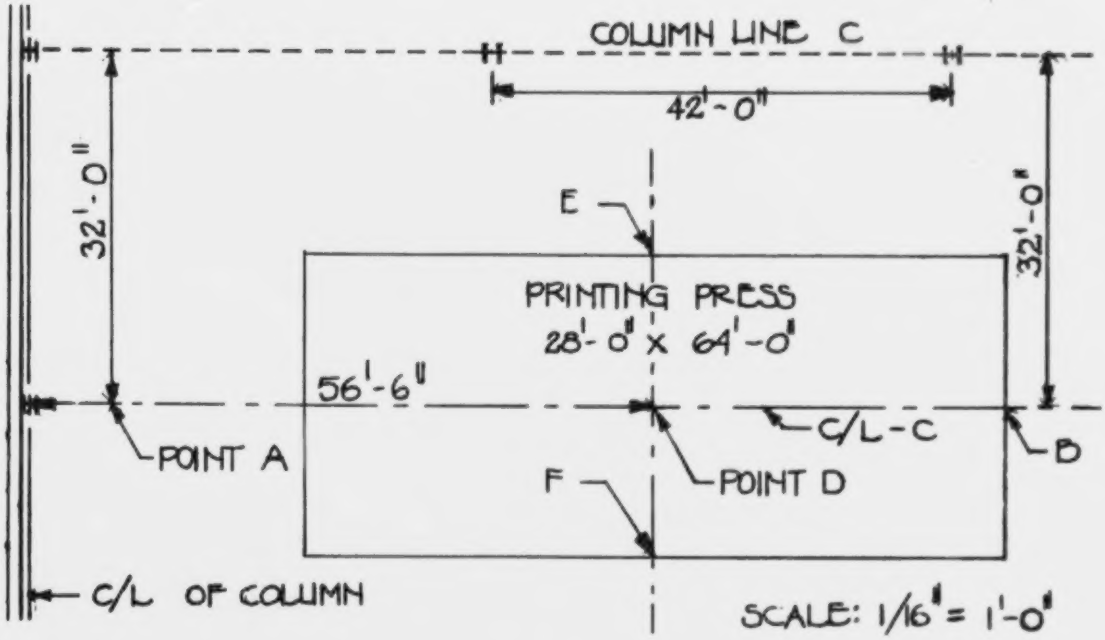
1. Measure out from center line of column line C 32'-0" and mark point A
2. Roughly 85'-0" from point A, measure out from column center line and again mark 32'-0" point B
3. Snap chalk line between these points to establish center line C
4. Measure out from center of west wall column line 56'-6" along C/L C to establish point D and mark
5. Set up instrument on point D
6. Sight through instrument along C/L C one direction
7. Turn instrument 180° and sight along C/L C at opposite end
8. Turn instrument 90°; approximately 15' from this point establish point E
9. Turn instrument 180° and establish point F
10. Snap chalk line between these points

(NOTE: Center lines are now established. You can now proceed to set equipment.)

Center Lines

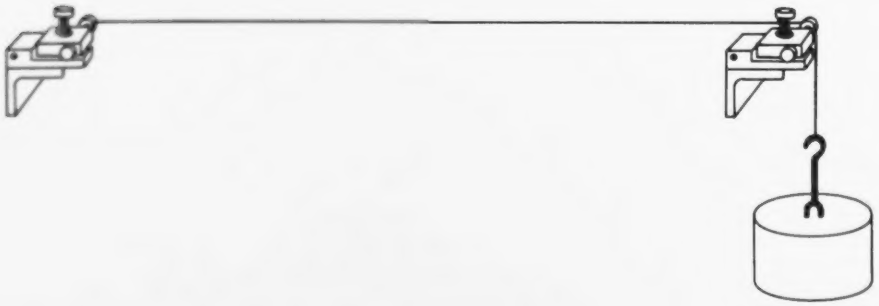


Establishing Lines with Floor Plugs

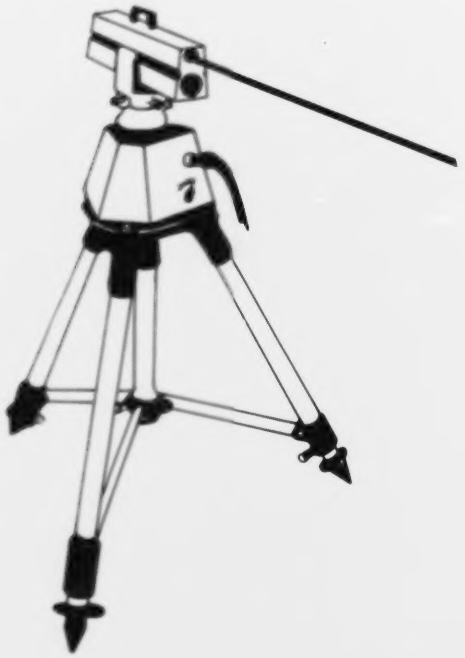

COLUMN LINE C
42'-0"
32'-0"
32'-0"
E
PRINTING PRESS
28'-0" x 64'-0"
56'-6"
C/L-C
B
POINT A
F
POINT D
C/L OF COLUMN
SCALE: 1/16" = 1'-0"

Establishing Center Lines with Instrument and Chalk Lines

Center Lines
(Continued)



Establishing Center Lines with Music Wire



Establishing Lines with Laser Beam

EQUIPMENT ALIGNMENT AND LEVELING
UNIT I

JOB SHEET #1--SET, ALIGN, AND LEVEL A PIECE OF EQUIPMENT

I. Tools and materials

A. Mechanic's level

B. Metal shims

C. Sole plate and jack bolts or anchor bolts

D. Assorted wrenches

E. Broom or brush

F. Chalk line and/or music wire

G. Blueprints

II. Procedure

A. Prepare (clean) foundation, anchor bolts, and sleeves

(NOTE: Never use jack bolts as anchor bolts.)

B. Establish center lines

C. Make a preliminary check of equipment

D. Set unit on anchor bolts or sole plates

(NOTE: Sole plates are not always used.)

E. Center equipment using center lines already established

F. Establish elevations

G. Level unit in both positions by using jack bolts and shims between bed plate or sole plate and concrete

H. Tighten anchor bolts

(NOTE: Always have anchor bolts tight before checking level.)

I. Recheck alignment and level before starting equipment

EQUIPMENT ALIGNMENT AND LEVELING
UNIT I

TEST

NAME ______________________________ SCORE ____________________

1. Match terms associated with alignment and leveling to the correct definitions by placing the appropriate numbers in the blanks provided.

______a. Proper positioning of equipment

______b. Setting equipment on horizontal plane in all directions

______c. Lines that are equal distance from each end and/or each side of equipment

______d. Tightly drawn, with no give or sag

______e. Metal plugs (usually brass) set in floor on exact center line dimensions used to set center lines and/or for future reference of center lines

______f. Lower plate on which some equipment is set and leveled

1. Center lines
2. Taut
3. Floor plugs
4. Equipment alignment
5. Sole plates
6. Equipment leveling

2. Name the popular and accurate methods of alignment.

a. ______________________________

b. ______________________________

c. ______________________________

3. Arrange in order the procedures to follow when setting and aligning equipment. Place a "1" in front of the first procedure, a "2" in front of the second procedure, and so on.

______a. Establish elevations

______b. Align equipment with center lines

______c. Set, align, and level sole plates

______d. Check anchor bolts for proper layout and length and damage

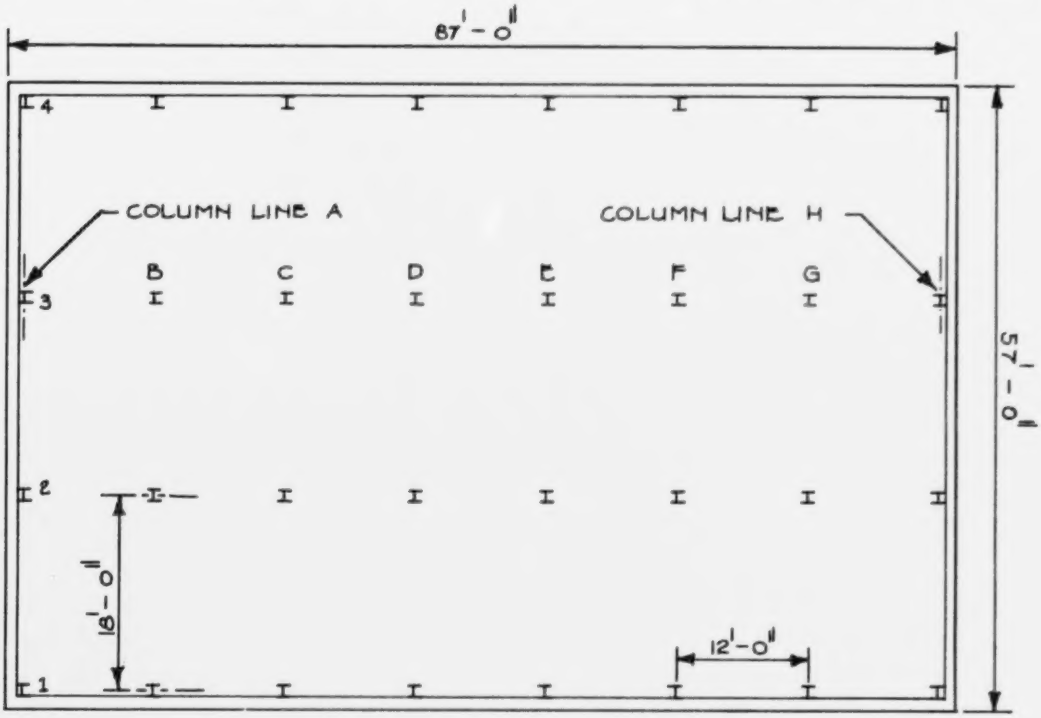
______e. Establish center lines

______f. Prepare (clean) foundation, anchor bolts, and sleeves ______g. Set equipment on sole plate

______h. Secure equipment

______i. Level equipment

4. Using drawings and dimensions below, establish and draw in center lines and/or offset center lines for equipment.
   a. Milling machine 7'-0" x 19'-0" should be 4'-0" from center line of column line 4 and 2'-0" north of center line of column line "2"
   b. Equipment base 4'-6" x 15'-6" should be 9'-6" west of center line at column line "D" and 2'-3" north of center line of column line "1"



MACHINE SHOP

SCALE: 1/16" = 1'-0"

5. Demonstrate the ability to set, align, and level a piece of equipment

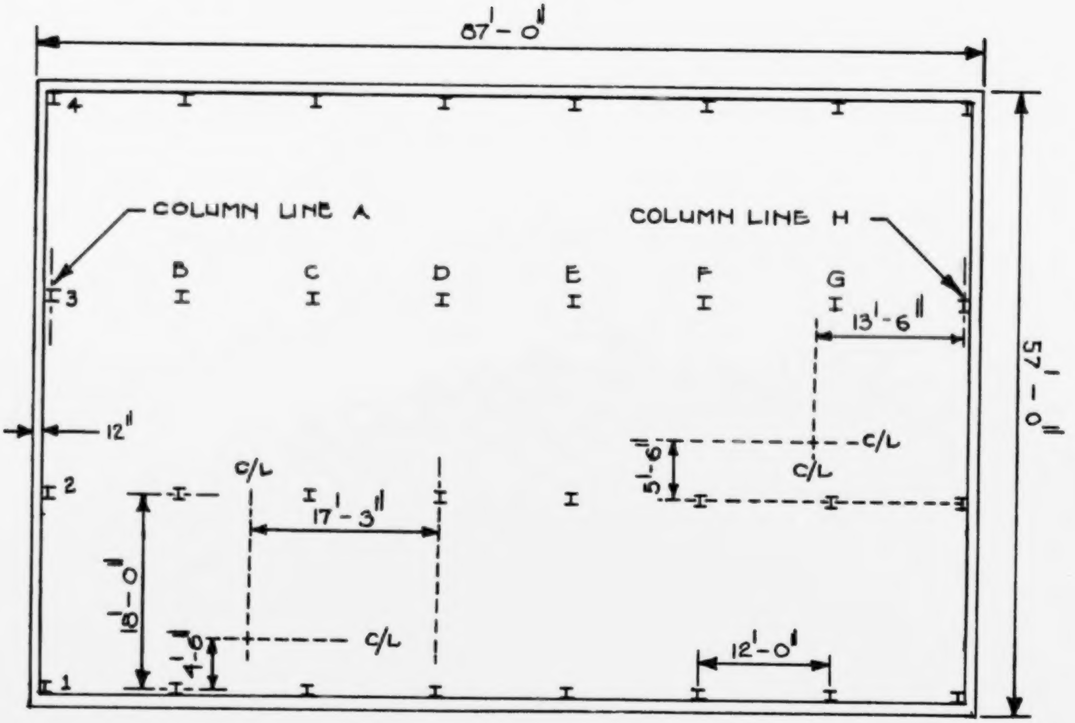
   (NOTE: If this activity has not been accomplished prior to the test, ask the instructor when it should be completed.)

EQUIPMENT ALIGNMENT AND LEVELING
UNIT I

ANSWERS TO TEST

1. a. 4
   b. 6
   c. 1
   d. 2
   e. 3
   f. 5
2. a. Center lines layed out on the floor using instrument
   b. Music wire (piano wire) stretched taut on center lines
   c. Laser beam
3. a. 3
   b. 7
   c. 5
   d. 4
   e. 2
   f. 1
   g. 6
   h. 9
   i. 8

4.


57'-0"
COLUMN LINE A
COLUMN LINE H
B
C
D
E
F
G
1
2
3
4
13'-6"
57'-0"
12"
C/L
17'-3"
C/L
5'-6"
C/L
18'-0"
4'-0"
C/L
12'-0"

MACHINE SHOP

SCALE: 1/16" = 1'-0"

5. Performance skill evaluated to the satisfaction of the instructor

OPERATION AND BASIC BALANCING
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to compute amount of force created by unbalance and correct static unbalance. This knowledge will be evidenced by completion of the assignment sheet, job sheet, and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with operation and basic balancing to the correct definitions.
2. List common sources of vibration.
3. Distinguish between basic types of unbalance.
4. Select from a list basic rules that determine when to balance.
5. Select from a list parts affected by unbalance.
6. List basic principals of balancing.
7. List reasons balancing is important.
8. State the formula for amount of force created by unbalance.
9. Compute amount of force created by unbalance
10. Demonstrate the ability to correct static unbalance.

OPERATION AND BASIC BALANCING
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information, assignment, and job sheets.

  C. Discuss unit and specific objectives.

  D. Discuss information and assignment sheets.

  E. Demonstrate and discuss procedures outlined in the job sheets.

  F. Give test.

II. Instructional materials:

  A. Objective sheet

  B. Information sheet

  C. Assignment Sheet #1--Compute Amount of Force Created by Unbalance

  D. Answers to assignment sheet

  E. Job Sheet #1--Correct Static Unbalance

  F. Test

  G. Answers to test

III. Unit reference--*"Dynamic Balancing: Application Report No. 111."* Columbus, Ohio: IRD Mechanalysis, 1977.

OPERATION AND BASIC BALANCING
UNIT II

INFORMATION SHEET

I. Terms and definitions

A. Vibration--Quivering or trembling motion

B. Balancing--Process by which the amount and position of heavy spot on a rotating unit is learned

C. Unbalance--Condition existing in a rotor when vibratory force or motion is imparted to its bearings as a result of centrifugal forces

D. Misalignment--Improper positioning of equipment

E. Dynamic--Mechanics that deal with forces and their relation to motion

F. Thermal growth--Expansion of equipment caused by rising heat of the equipment

G. Colinear--Having corresponding parts arranged in the same linear order

H. Gravity--Attractive force that tends to draw an object toward the center of the earth

I. Heavy spot--Position of greatest amount of weight

J. Static--Exerting force by reason of weight alone without motion

K. Vector--Line whose length represents amount of unbalance and whose direction represents angle of unbalance

II. Common sources of vibration

(NOTE: These are only a few of the many causes of vibration, but probably the most common.)

A. Unbalance

B. Misalignment

(NOTE: Alignment is one of the most misunderstood subjects in the field of maintenance. Major coupling manufacturers advertise the degree of permissible misalignment of their particular unit, and, from this information, the user assumes that if the unit is within these limits, it is good enough. This is not so, however, for barely tolerable alignment yields barely tolerable operation. Misalignment, or the deviation from colinear shaft conditions, will show itself as wasted energy and problems.)

INFORMATION SHEET

C. Lack of or too much lubrication

D. Improper clearances on couplings and bearings

E. Bent shafts

F. Assembly errors

G. Inconsistency of materials

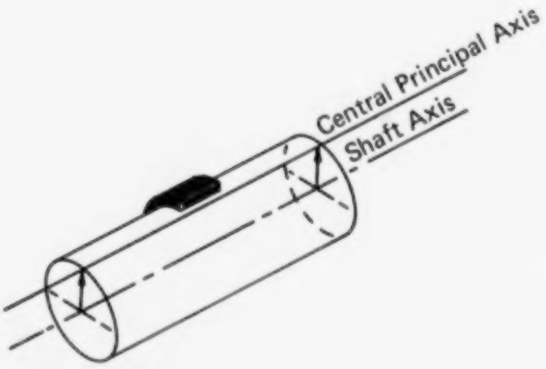
(NOTE: These include poor quality materials, improperly mated materials, or improperly assembled materials.)

H. Thermal growth

III. Basic types of unbalance

(NOTE: Static unbalance can usually be detected by using conventional gravity-type knife edge balancing method, while dynamic unbalance necessitates use of special balancing machines, special skills, and experience.)

A. Static--Condition of unbalance where central principal axis is displaced parallel to rotating center line



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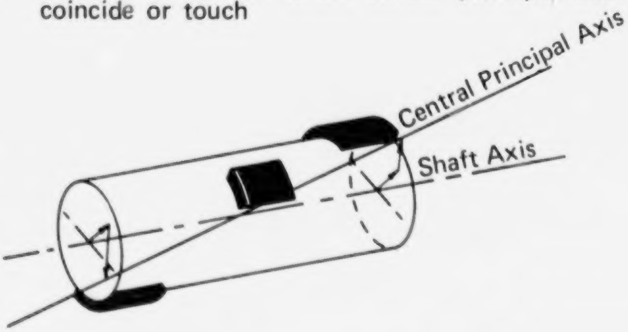
INFORMATION SHEET

B. Dynamic--Condition where central principal axis and rotating center line coincide or touch



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IV. Basic rules that determine when to balance

   A. Elements operating at speeds in excess of 180 RPM

   B. Elements with outer diameters of five inches or greater

   C. Elements that must operate near their critical speed

   D. Elements that must maintain specific space relationship with other parts while in operation

V. Parts affected by unbalance

   A. Rotor

   B. Bearings

   C. Couplings

   D. Supporting structure

   E. Equipment itself

VI. Basic principles of balancing

   A. Determine amount of heavy spot

   B. Determine position of heavy spot

   C. Determine if weight needs to be added or removed

   D. Determine speed (RPM) of equipment

   E. Determine radius

VII. Reasons balancing is important

   A. Forces created by unbalance are detrimental to the life of the machine, rotor, bearings, and supporting structures

INFORMATION SHEET

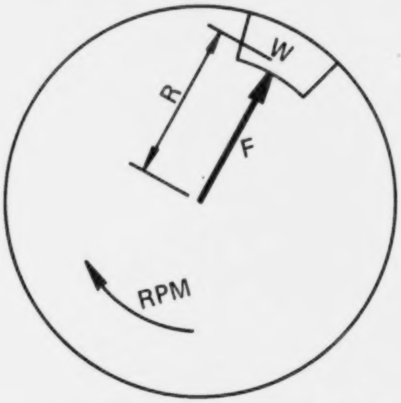
B. Unwanted vibration and poor product quality often result from unbalance

VIII. Formula for amount of force created by unbalance (Assignment Sheet #1)

(NOTE: The amount of force created by unbalance depends on the speed of rotation and the amount of unbalance. For very high speed machines, a relatively small unbalance weight can produce a tremendous amount of force.)

F = Force in pounds
1.77= Constant required to make formula dimensionally correct
RPM = Rotating speed
W = Unbalance weight
R = Distance of unbalance weight from center line

$$F = 1.77 \times (RPM/1000)^2 \times W \times R$$



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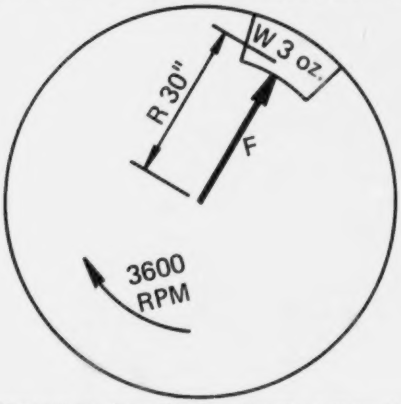
Example: $F = 1.77 \times (3600/1000)^2 \times 3 \times 30$
$= 1.77 \times 3.6^2 \times 3 \times 30$
$= 1.77 \times 12.96 \times 3 \times 30$
$F = 2064.528$ pounds rounded to 2065 pounds



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OPERATION AND BASIC BALANCING
UNIT II

ASSIGNMENT SHEET #1--COMPUTE AMOUNT OF FORCE CREATED BY UNBALANCE

1. Compute amount of force created by unbalance. Use the back of this page to show your work.

Formula: $F = 1.77 \times (RPM/1000)^2 \times W \times R$

1.77 = Constant required to make formula dimensionally correct
RPM = Rotating speed
W = Unbalance weight
R = Distance of unbalance weight from centerline

a. ______ $= 1.77 \times (1800/1000)^2 \times 1\ 1/2$ oz × 18"

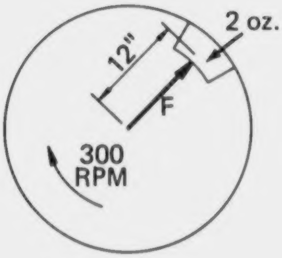
b. ______ $= 1.77 \times (600/1000)^2 \times 3$ oz × 24"

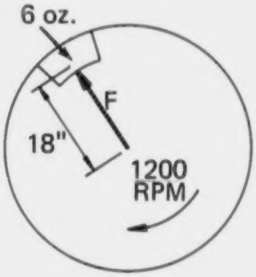
c. ______ $= 1.77 \times (7200/1000)^2 \times 8$ oz × 36"

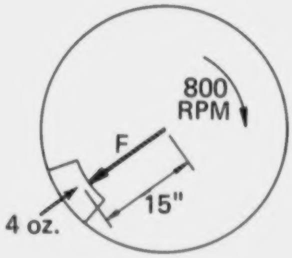
d. ______ $= 1.77 \times (3000/1000)^2 \times 5$ oz × 20"

e. ______ $= 1.77 \times (2400/1000)^2 \times 3$ oz × 30"

2. Compute the amount of force created by unbalance on each of the following problems. Use the back of this page to show your work.







a. ________________ b. ________________ c. ________________

OPERATION AND BASIC BALANCING
UNIT II

ANSWERS TO ASSIGNMENT SHEET

Assignment Sheet #1

1. a. 155 lbs
   b. 46 lbs
   c. 26,426 lbs
   d. 1,593 lbs
   e. 918 lbs
2. a. 38 lbs
   b. 275 lbs
   c. 68 lbs

OPERATION AND BASIC BALANCING
UNIT II

JOB SHEET #1--CORRECT STATIC UNBALANCE

I. Tools and equipment

   A. Rotor

   B. Weights, assorted sizes

   C. Tool to install weights (usually a welder)

II. Procedure

   A. Find heavy side of rotor by setting in several positions

   (NOTE: Heavy side of rotor will swing to the bottom.)

   B. Add or remove correction weight as required (Figures 1 and 2)

   (NOTE: Static unbalance can be corrected by adding or removing weight in only one correction plane; however, making the correction in the proper plane is important.)

FIGURE 1

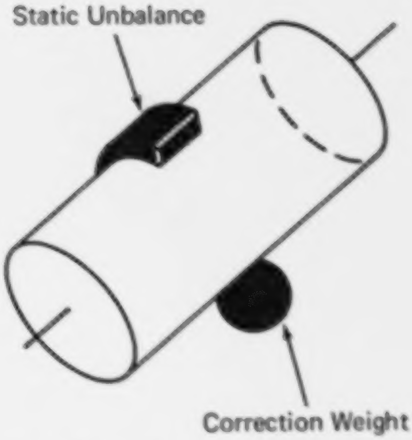
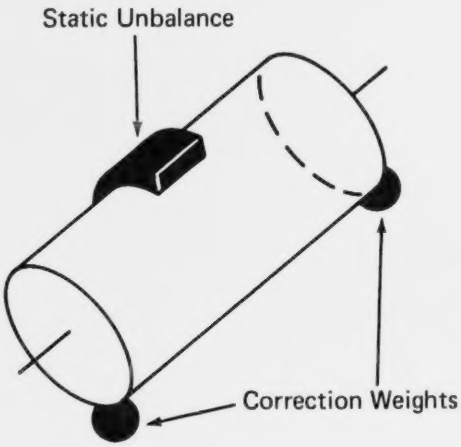


FIGURE 2



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   C. Use welder to tack weld weights

OPERATION AND BASIC BALANCING
UNIT II

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with operation and basic balancing to the correct definitions. Place the correct numbers in the blanks provided.

______a. Quivering or trembling motion

______b. Process by which the amount and position of heavy spot on a rotating unit is learned

______c. Condition existing in a rotor when vibratory force or motion is imparted to its bearings as a result of centrifugal forces

______d. Improper positioning of equipment

______e. Mechanics that deal with forces and their relation to motion

______f. Expansion of equipment caused by rising heat of the equipment

______g. Having corresponding parts arranged in the same linear order

______h. Attractive force that tends to draw an object toward the center of the earth

______i. Position of greatest amount of weight

______j. Exerting force by reason of weight alone without motion

______k. Line whose length represents amount of unbalance and whose direction represents angle of unbalance

1. Misalignment
2. Colinear
3. Heavy spot
4. Vibration
5. Dynamic
6. Static
7. Balancing
8. Vector
9. Gravity
10. Thermal growth
11. Unbalance

2. List common sources of vibration.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ____

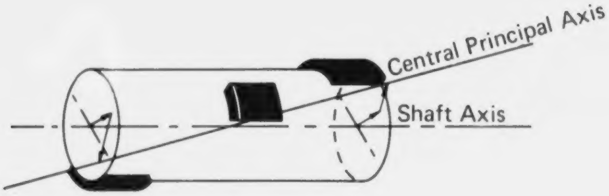
f. ____

g. ____

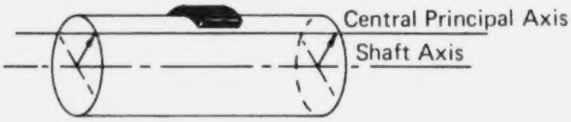
h. ____

3. Distinguish between basic types of unbalance. Place an "X" in the blank defining static unbalance..

   ______a. Condition where central principal axis and rotating center line coincide or touch



   ______b. Condition of unbalance where central principal axis is displaced parallel to rotating center line



4. Select from the list below basic rules that determine when to balance. Place an "X" in the correct blanks.

   ______a. Elements that must maintain specific space relationship with other parts while in operation

   ______b. Elements that operate above critical speed

   ______c. Elements with outer diameters of five inches or less

   ______d. Elements operating at speeds in excess of 180 RPM

   ______e. Elements operating at speeds of 180 RPM or less

5. Select from the list below parts affected by unbalance. Place an "X" in the correct blanks.

   ______a. Equipment itself

   ______b. Housing

   ______c. Couplings

   ______d. Supporting structure

   ______e. RPM

   ______f. Bearings

   ______g. Rotation

   ______h. Rotor

6. List three basic principals of balancing.

   a. ____

   b. ____

   c. ____

7. List reasons balancing is important.

   a. ____

   ____

   b. ____

   ____

8. State the formula for amount of force created by unbalance.

9. Compute amount of force created by unbalance.

10. Demonstrate the ability to correct static unbalance.

   (NOTE: If activities 9 and 10 have not been accomplished prior to the test, ask the instructor when they should be completed.)

OPERATION AND BASIC BALANCING
UNIT II

ANSWERS TO TEST

1. a. 4
   b. 7
   c. 11
   d. 1
   e. 5
   f. 10
   g. 2
   h. 9
   i. 3
   j. 6
   k. 8
2. a. Unbalance
   b. Misalignment
   c. Lack of or too much lubrication
   d. Improper clearances on couplings and bearings
   e. Bent shafts
   f. Assembly errors
   g. Inconsistency of materials
   h. Thermal growth
3. b
4. a, d
5. a, c, d, f, h
6. Any three of the following:
   a. Determine amount of heavy spot
   b. Determine position of heavy spot
   c. Determine if weight needs to be added or removed
   d. Determine speed (RPM) of equipment
   e. Determine radius

7. a. Forces created by unbalance are detrimental to the life of the machine, rotor, bearings, and supporting structures

   b. Unwanted vibration and poor product quality often result from unbalance

8. $F = 1.77 \times (RPM/1000)^2 \times W \times R$

9. Evaluated to satisfaction of instructor

10. Performance skill evaluated to satisfaction of instructor

MILLWRIGHT INSTRUCTIONAL MATERIALS
PROGRESS CHART

Section H
Equipment Hookup and Operation

Student's Name	UNIT I EQUIPMENT ALIGNMENT and LEVELING						UNIT II OPERATION and BASIC BALANCING													
	1	2	3	4	5	6	1	2	3	4	5									
Job	Unit Test	Set, Align, and Level a Piece of Equipment					Unit Test	Compute Amount of Force Created by Unbalance	Correct Static Unbalance											
1																				
2																				
3																				
4																				
5																				
6																				

Accuracy	85% Correct	To Satisfaction of Instructor					85% Correct	To Satisfaction of Instructor	To Satisfaction of Instructor											
8																				
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				

MILLWRIGHT INSTRUCTIONAL MATERIALS
PROGRESS CHART

Section H
Equipment Hookup and Operation

	UNIT I EQUIPMENT ALIGNMENT and LEVELING						UNIT II OPERATION and BASIC BALANCING													
	1	2	3	4	5	6	1	2	3	4	5									
Job Student's Name	Unit Test	Set, Align, and Level a Piece of Equipment					Unit Test	Compute Amount of Force Created by Unbalance	Correct Static Unbalance											
1																				
2																				
3																				
4																				
5																				
6																				
7																				

		Accuracy																			
		85% Correct	To Satisfaction of Instructor					85% Correct	To Satisfaction of Instructor	To Satisfaction of Instructor											
8																					
9																					
10																					
11																					
12																					
13																					
14																					
15																					
16																					
17																					
18																					
19																					
20																					

PUMPS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list different types of pumps and be able to set, align, and level a pump. This knowledge will be evidenced by completion of the job sheets and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with pumps to the correct definitions.
2. List types of pumps.
3. Select from a list features of centrifugal pumps.
4. List types of positive displacement used in reciprocating pumps.
5. Select from a list elements used in rotary pumps to move liquids.
6. Describe standard pump ratings in general use.
7. Identify types of anchors used for pump installation.
8. Arrange in order steps to follow when installing a pump.
9. Demonstrate the ability to:
    a. Set, align, and level a vertical pump.
    b. Set, align, and level a horizontal pump.

PUMPS
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide students with objective sheet.

  B. Provide students with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss procedures outlined in job sheets.

  G. Give test.

II. Instructional materials:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Types of Pumps

    2. TM 2--Types of Pumps (Continued)

    3. TM 3--Types of Pumps (Continued)

    4. TM 4--Types of Pumps (Continued)

    5. TM 5--Types of Pumps (Continued)

    6. TM 6--Types of Pumps (Continued)

    7. TM 7--Types of Pumps (Continued)

    8. TM 8--Types of Anchors

  D. Job sheets

    1. Job Sheet #1--Set, Align, and Level a Vertical Pump

    2. Job Sheet #2--Set, Align, and Level a Horizontal Pump

E. Test

F. Answers to test

III. Unit reference--*Construction Millwright I: Training Module.* Houston, Texas: Brown and Root, Inc., n.d.

PUMPS
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Pumps--Mechanical devices that convey liquids against force of gravity

B. Centrifugal--Proceeding in a direction away from the center of an axis

C. Reciprocating--Alternating back and forth motion of pistons

D. Coupling--Device used to connect two co-axial shafts together so power can be transmitted from motor shaft to pump shaft

E. Rotary--Turning on an axis

Examples: Impeller, gear

F. Suction head--Vertical distance in feet from supply level to pump center line with pump below supply level

G. Discharge head--Vertical distance in feet from pump center line to point of free delivery

H. Total head (head lift)--Distance which pump lifts liquid

I. Suction lift--Distance liquid must be lifted up to pump

J. Diaphragm--Thin, flexible material fastened securely around perimeter with center moved back and forth to provide displacing action

K. Impeller--Part of a pump that applies high energy force to fluid to supply velocity and momentum

L. Run-out--Amount of misalignment on a rotating shaft that is read by an indicator

II. Types of pumps (Transparencies 1-7)

A. Centrifugal

B. Reciprocating

C. Rotary

D. Propeller

INFORMATION SHEET

E. Turbine

F. Diaphragm

G. Helical

(NOTE: Types of pumps also include gasoline, air, and steam-driven in addition to the electric pumps listed.)

III. Features of centrifugal pumps

A. Simple design

B. Relatively low cost

C. Efficient for large capacities and low pressures

D. Do not clog when pumping liquids containing foreign matter

IV. Types of positive displacement used in reciprocating pumps

A. Piston

B. Plunger

C. Diaphragm

V. Elements used in rotary pumps to move liquids

A. Vanes

B. Gears

C. Lobes

D. Cams

VI. Standard pump ratings in general use

A. Gallons per minute (GPM)--Volume of liquid delivered by pump

B. Pounds per square inch (PSI)--Pressure at which liquid is moved

VII. Types of anchors used for pump installation (Transparency 8)

(NOTE: These are only a few of the many types that may be used.)

A. Expansion bolt

B. Anchor bolt

C. Jack bolts

D. Wedge anchor

INFORMATION SHEET

VIII. Steps to follow when installing a pump

(NOTE: Before starting, check manufacturer's specifications.)

A. Prepare (clean) foundation, anchor bolts, and sleeves

B. Locate center lines

(NOTE: If center lines are not located by floor plugs or floormarkings, it may be necessary to refer to plans or specifications.)

C. Check anchor bolts for proper length, proper layout, and damage

D. Set and align sole plate using jack bolts and shims or anchor bolts

(NOTE: Not all pumps are set on sole plates.)

E. Set pump on anchor bolts

F. Align pump discharge and/or intake to center lines on floor or to music wire as reference points

(NOTE: Be sure pump is set high enough to allow motor alignment.)

G. Level pump

(NOTE: Pump discharge and intake must be level and plumb in all directions.)

H. Secure pump

I. Proceed with coupling alignment

(NOTE: Do not make up coupling until motor rotation matches pump rotation.)

(CAUTION: Pump turning in wrong rotation will ruin equipment.)

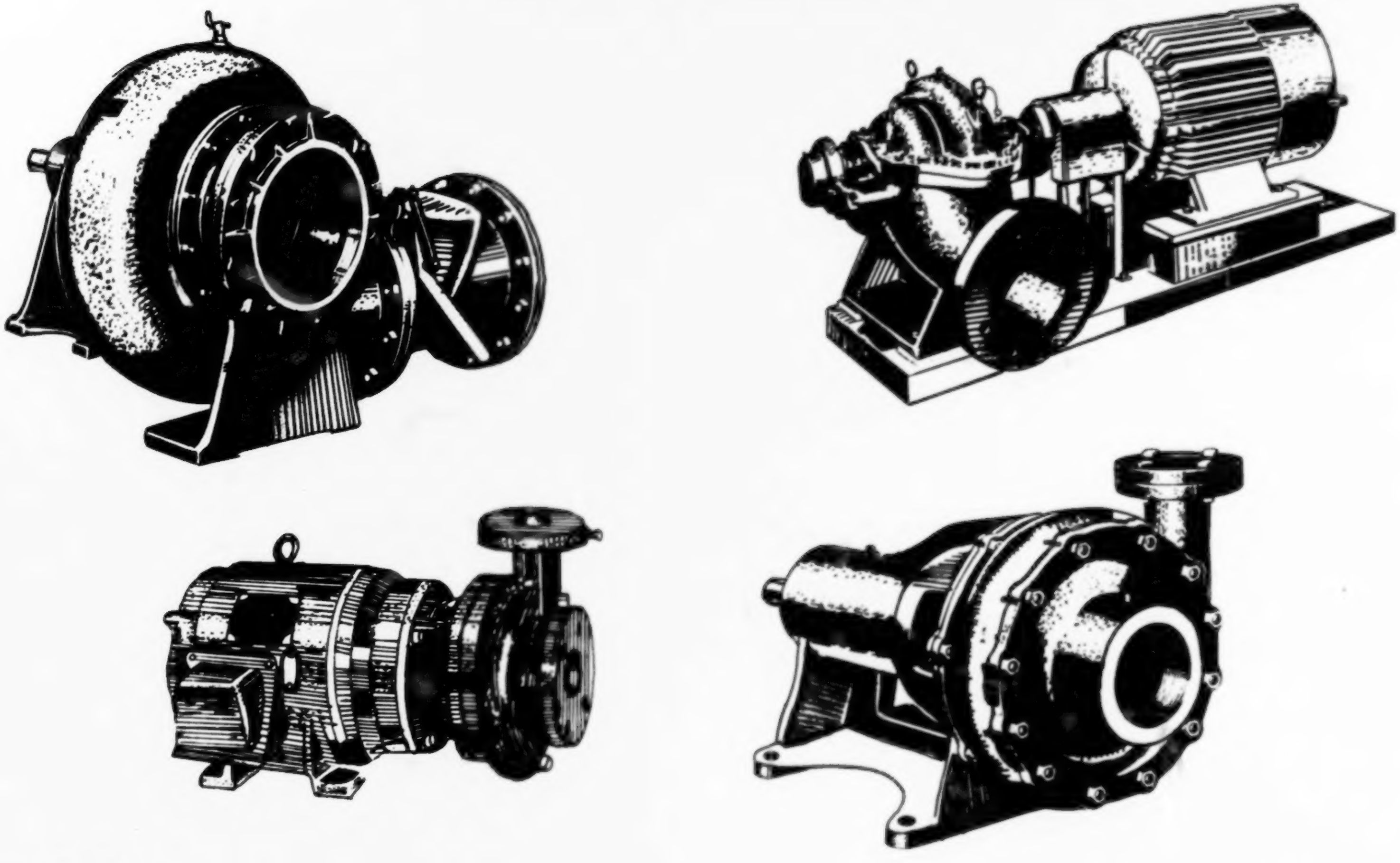
J. Check pump for lubrication

K. Install packing

L. Dowel feet to pump base if required

Types of Pumps

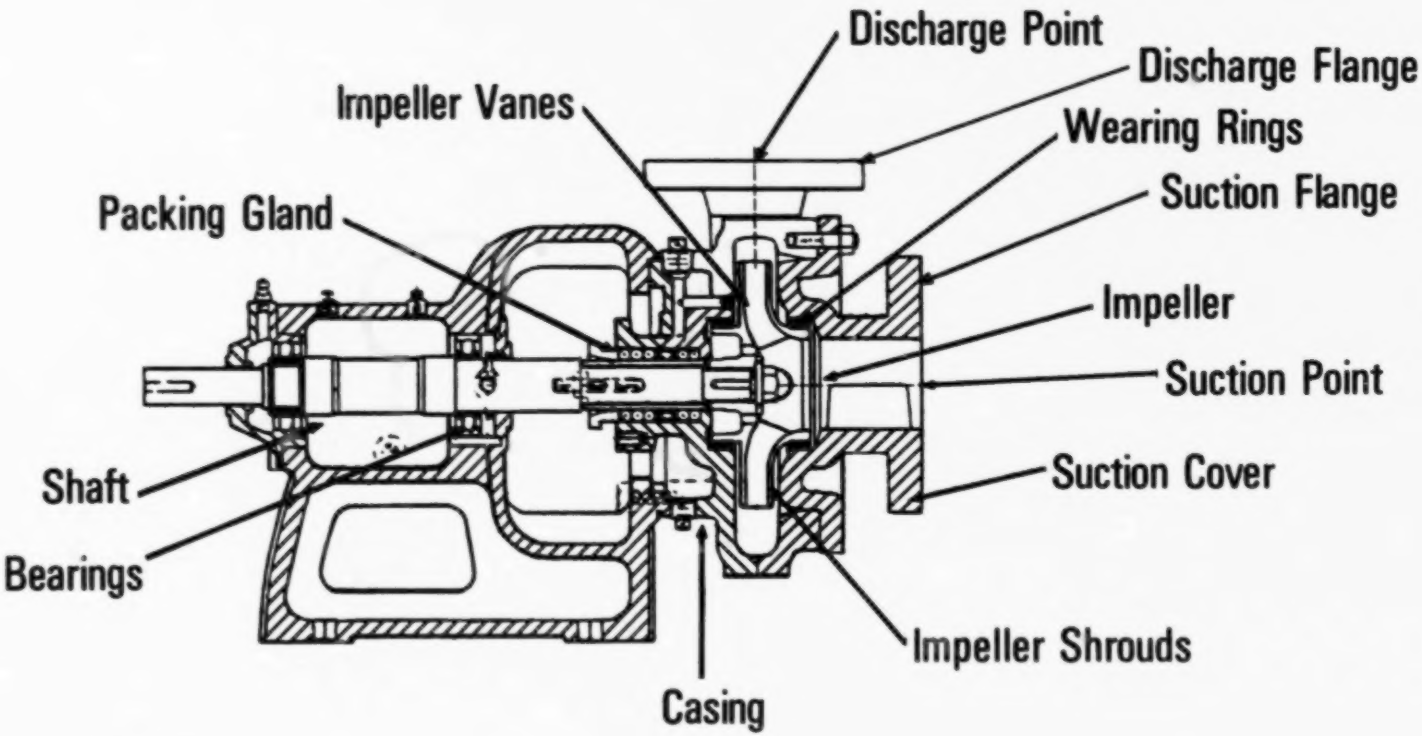
Centrifugal Pumps



Types of Pumps

(Continued)

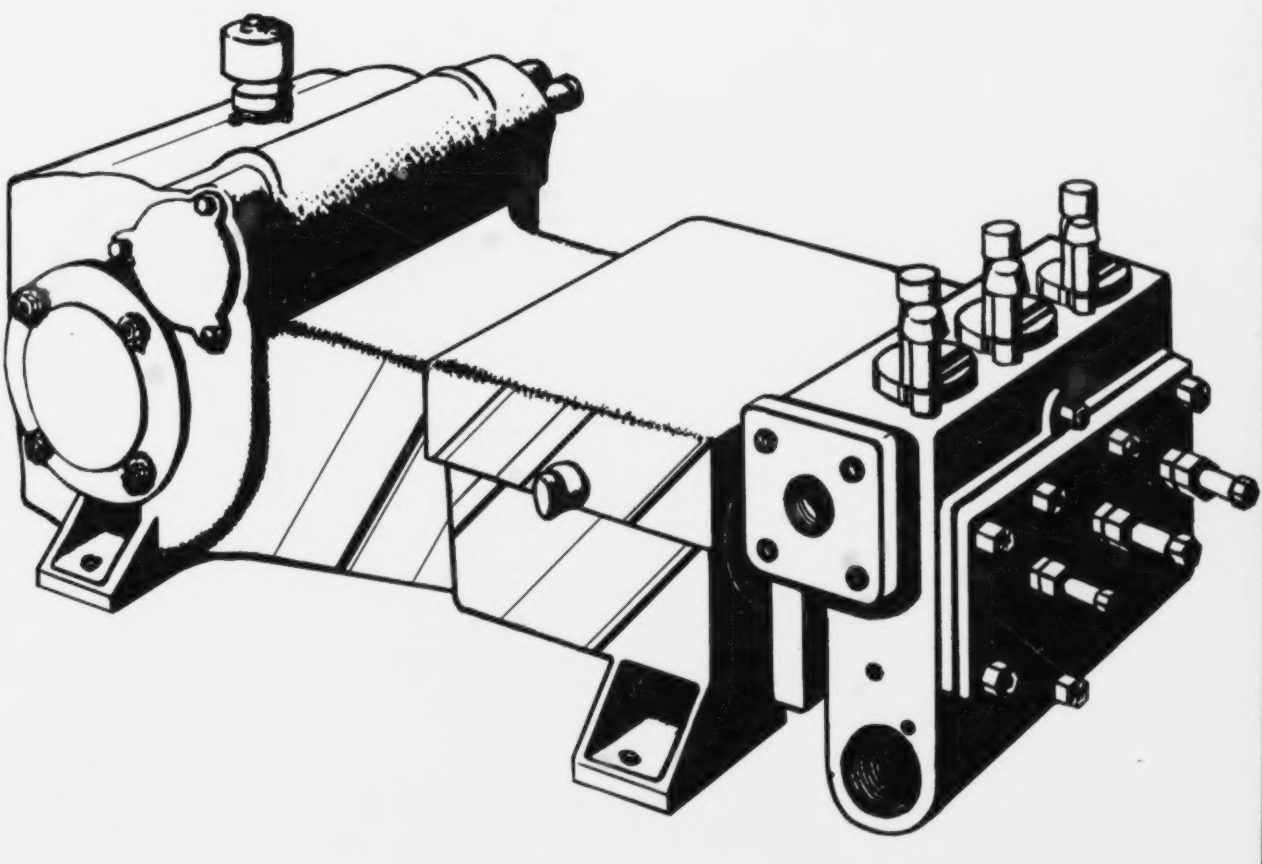
Cross Section of Centrifugal Pump


Discharge Point
Discharge Flange
Impeller Vanes
Wearing Rings
Suction Flange
Packing Gland
Impeller
Suction Point
Suction Cover
Shaft
Bearings
Impeller Shrouds
Casing

Types of Pumps

(Continued)

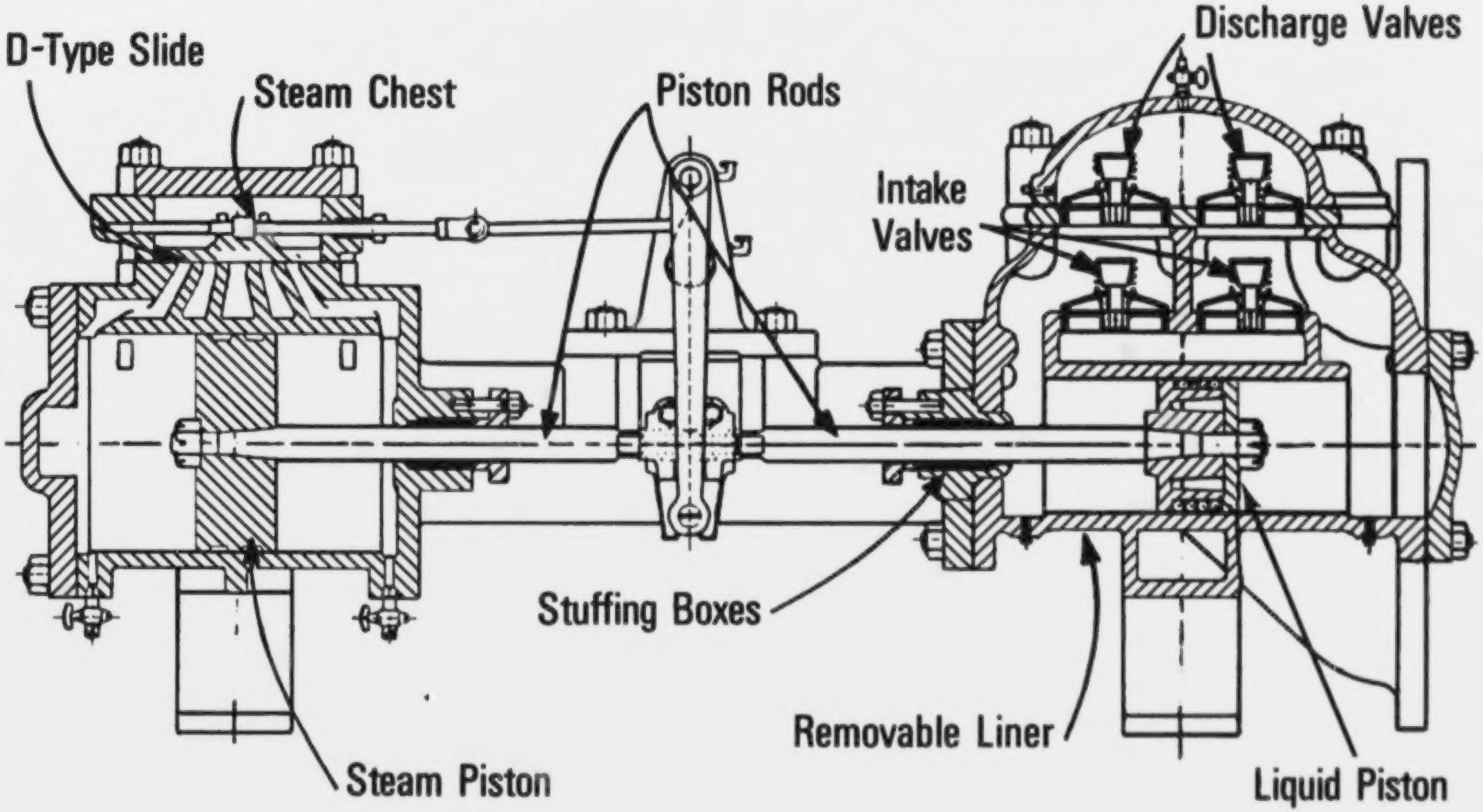
Reciprocating Pump



Types of Pumps

(Continued)

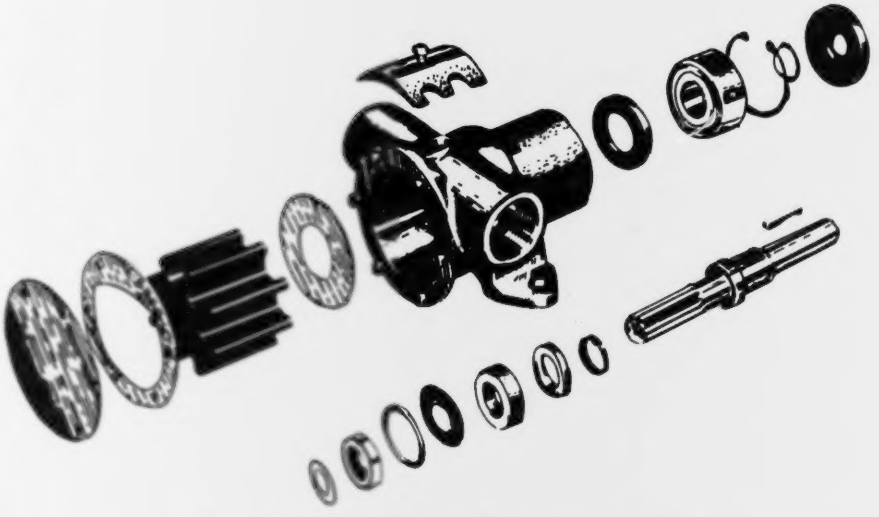
Cross Section of Reciprocating Pump


D-Type Slide
Steam Chest
Piston Rods
Discharge Valves
Intake Valves
Stuffing Boxes
Removable Liner
Steam Piston
Liquid Piston

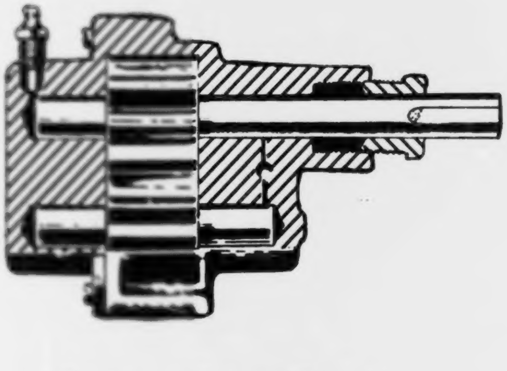
Types of Pumps

(Continued)

Rotary Pumps

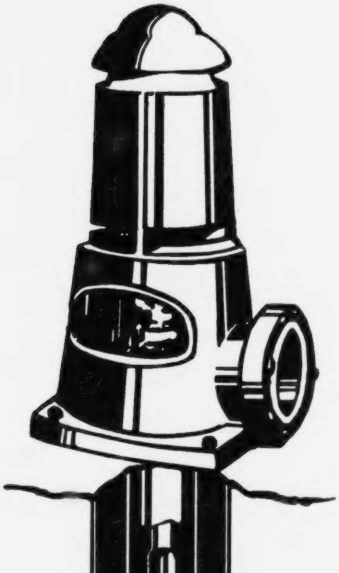


Flexible Impeller Rotary Pump

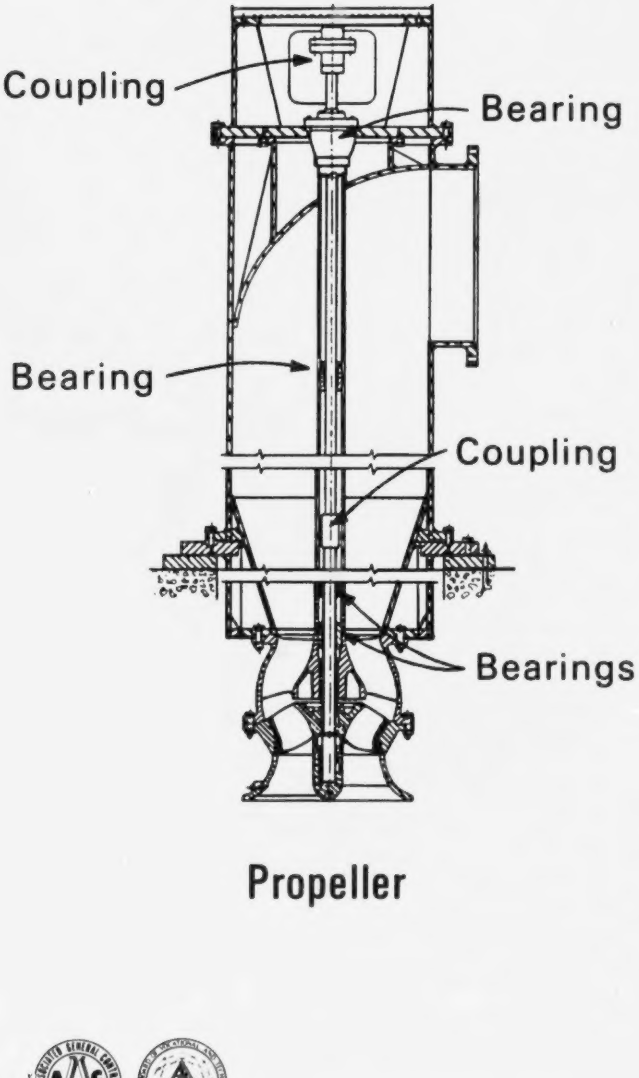


Rotary Gear Pump

Types of Pumps
(Continued)



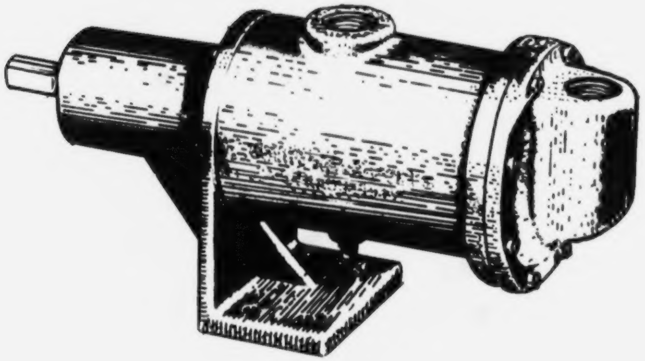
Turbine


Coupling
Bearing
Bearing
Coupling
Bearings

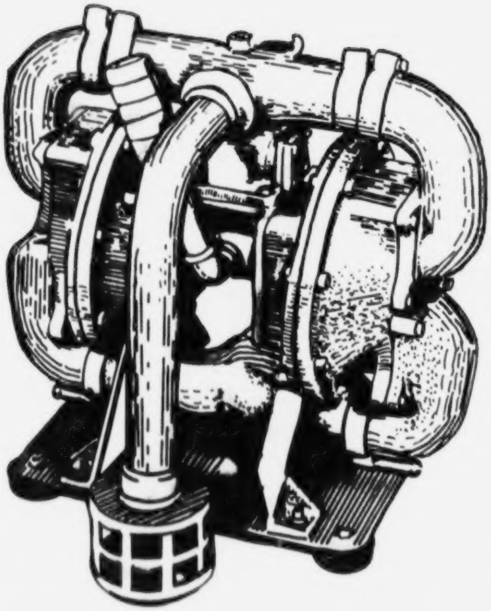
Propeller

Types of Pumps

(Continued)

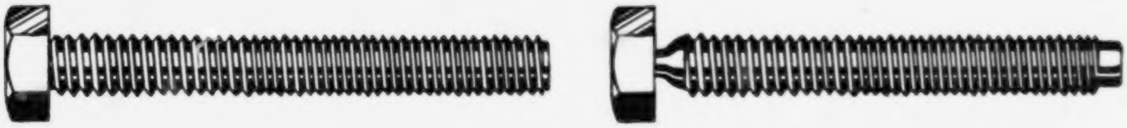


Helical

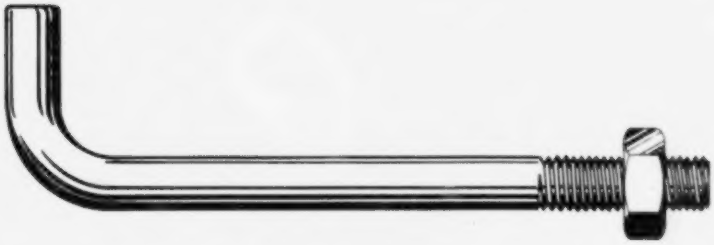


Diaphragm

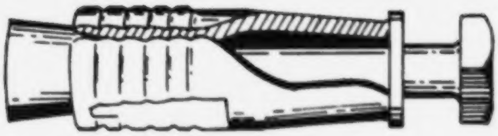
Types of Anchors



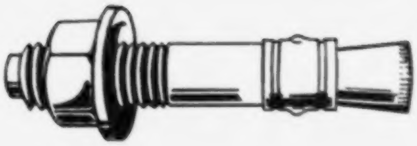
Jack Bolts



Anchor Bolt



Expansion Bolt



Wedge Anchor

PUMPS
UNIT I

JOB SHEET #1--SET, ALIGN, AND LEVEL A VERTICAL PUMP

I. Tools and materials

- A. Broom or brush
- B. Steel tapes, 100' and 8'
- C. Lifting device
- D. Mechanic's level
- E. Assorted wrenches
- F. Plumb bob
- G. Jack bolts
- H. Shims, assorted sizes and thicknesses
- I. Sole plate
- J. Pump unit
- K. Chalk line and/or piano wire

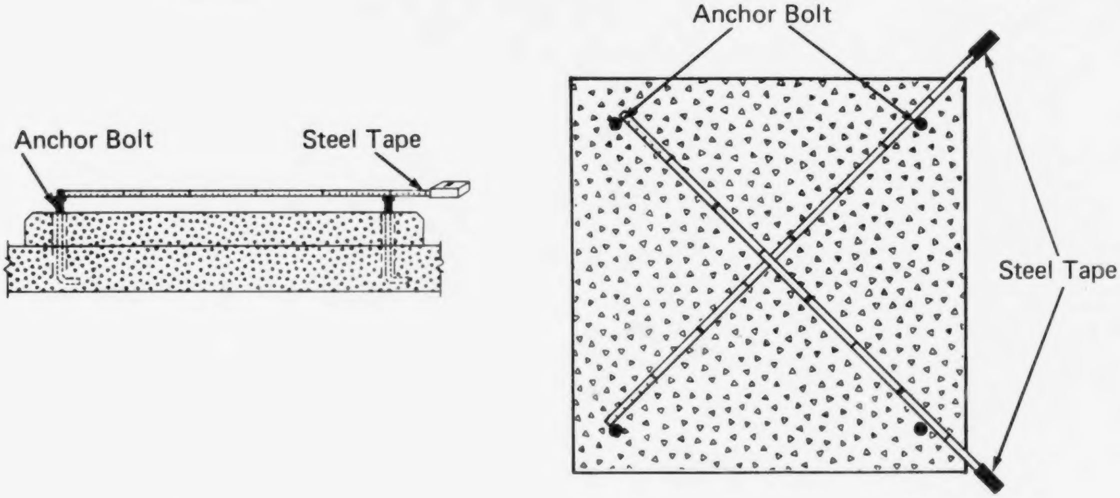
II. Procedure

- A. Prepare (clean) foundation, anchor bolts, and sleeves prior to installation
- B. Establish center lines

JOB SHEET #1

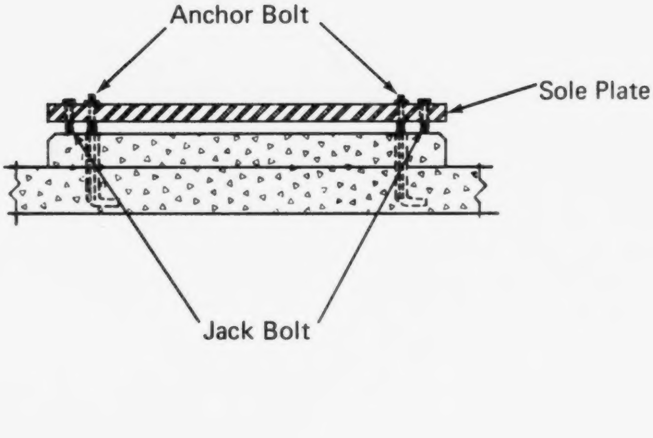
C. Check anchor bolts for proper length, proper layout, and damage (Figure 1)

FIGURE 1


Anchor Bolt
Steel Tape
Anchor Bolt
Steel Tape

D. Install sole plate (Figure 2)

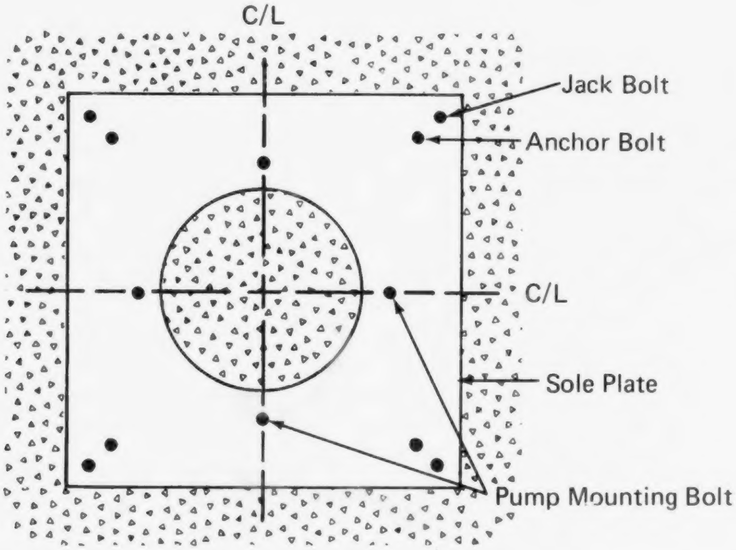
FIGURE 2


Anchor Bolt
Sole Plate
Jack Bolt

JOB SHEET #1

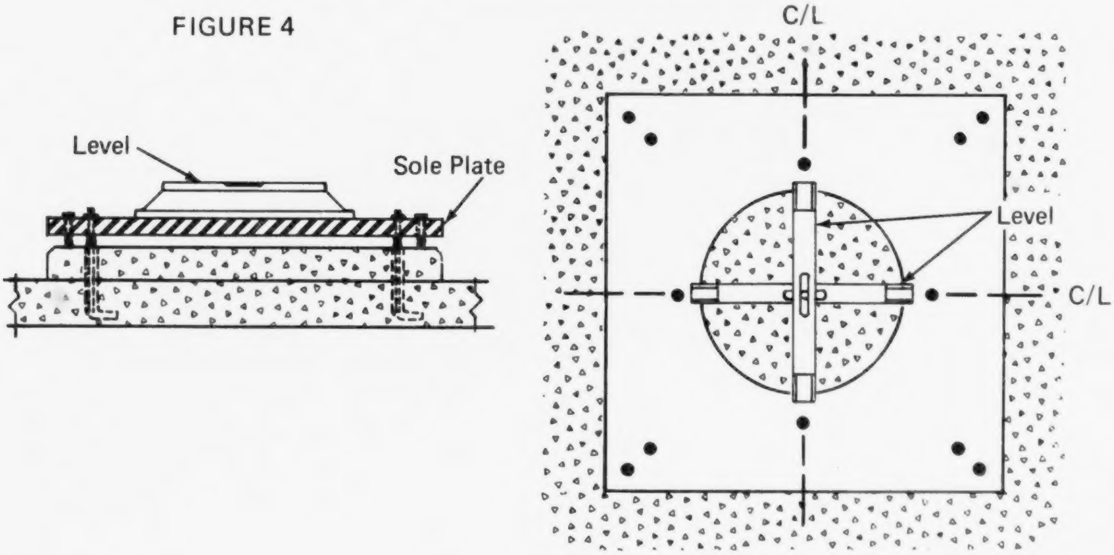
E. Align sole plate to center lines (Figure 3)

FIGURE 3


C/L
Jack Bolt
Anchor Bolt
C/L
Sole Plate
Pump Mounting Bolt

F. Level sole plate using level in both directions and adjusting jack bolts or shims to set at established elevation (Figure 4)

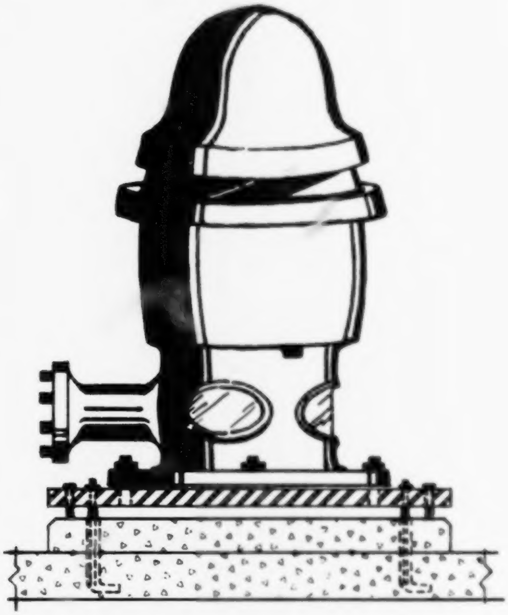
FIGURE 4


Level
Sole Plate
C/L
Level
C/L

JOB SHEET #1

G. Install pump on sole plate (Figure 5)

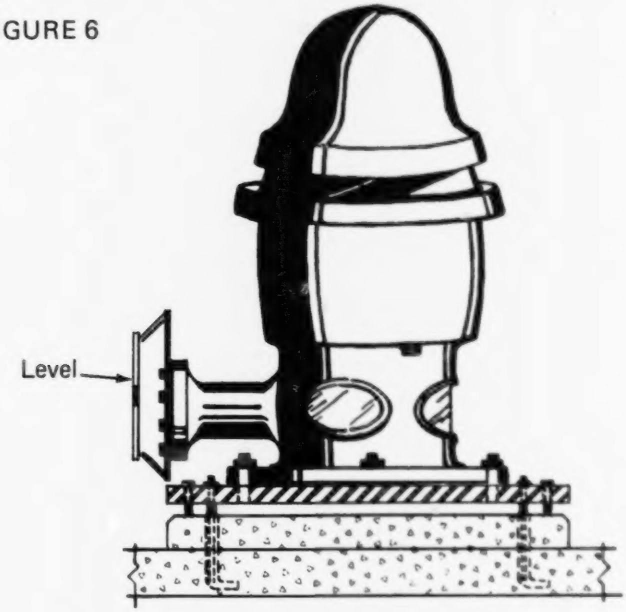
FIGURE 5



H. Align pump to center lines by dropping plumb bob from center line of discharge flange to center line established on floor

I. Place mechanic's level on discharge flange and check for plumb (Figure 6)

FIGURE 6



JOB SHEET #1

J. If necessary, level pump by adjusting jack bolts and shims under sole plate

(NOTE: Always be sure anchor bolts are tight before reading level.)

K. Recheck anchor bolts and center line when pump is level

L. Check pump for lubrication

M. Install packing

N. Dowel feet to pump base if required

PUMPS
UNIT I

JOB SHEET #2--SET, ALIGN, AND LEVEL A HORIZONTAL PUMP

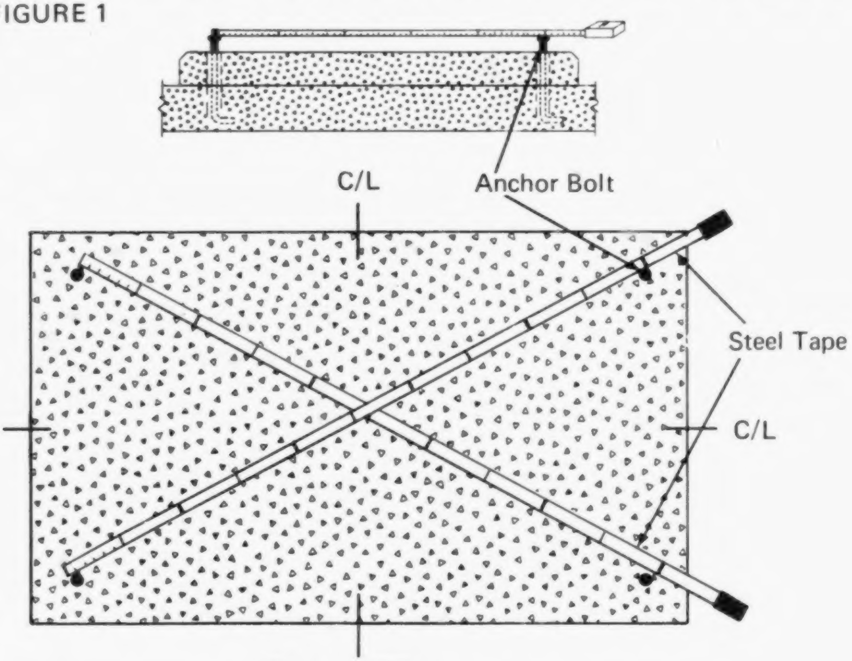
I. Tools and materials

- A. Mechanic's level
- B. Metal shims and wedges
- C. Assorted wrenches
- D. Broom or brush
- E. Chalk line
- F. Plumb bob
- G. Steel tapes, 100' and 8'
- H. Blueprints

II. Procedure

- A. Prepare (clean) foundation, anchor bolts, and sleeves prior to installation (NOTE: Never use anchor bolts as jack bolts.)
- B. Establish center lines
- C. Make preliminary check of motor pump for alignment
- D. Check anchor bolts for proper length, proper layout, and damage (Figure 1)

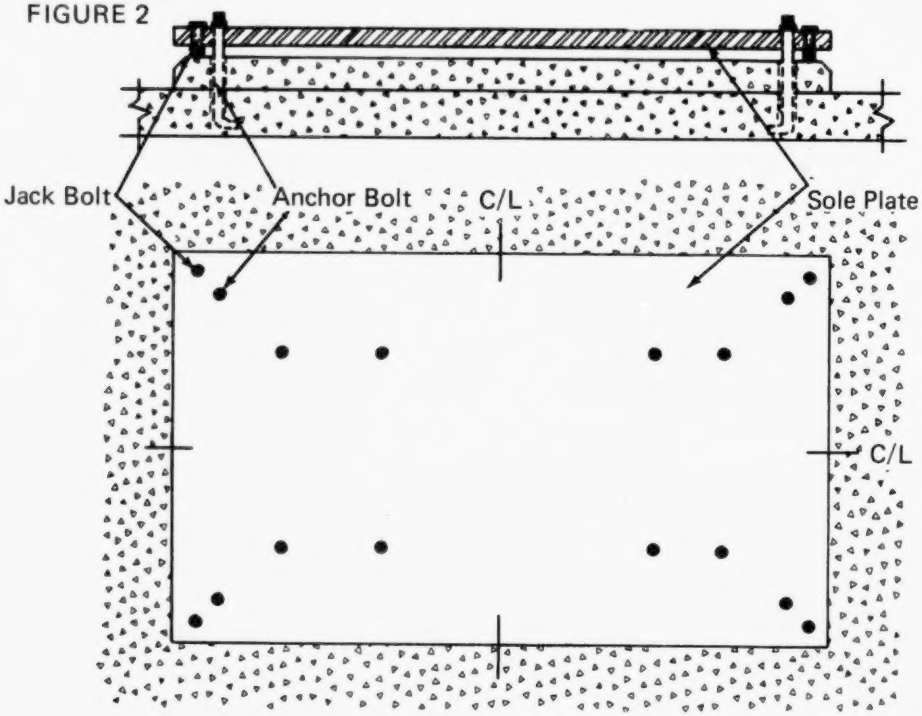
FIGURE 1



JOB SHEET #2

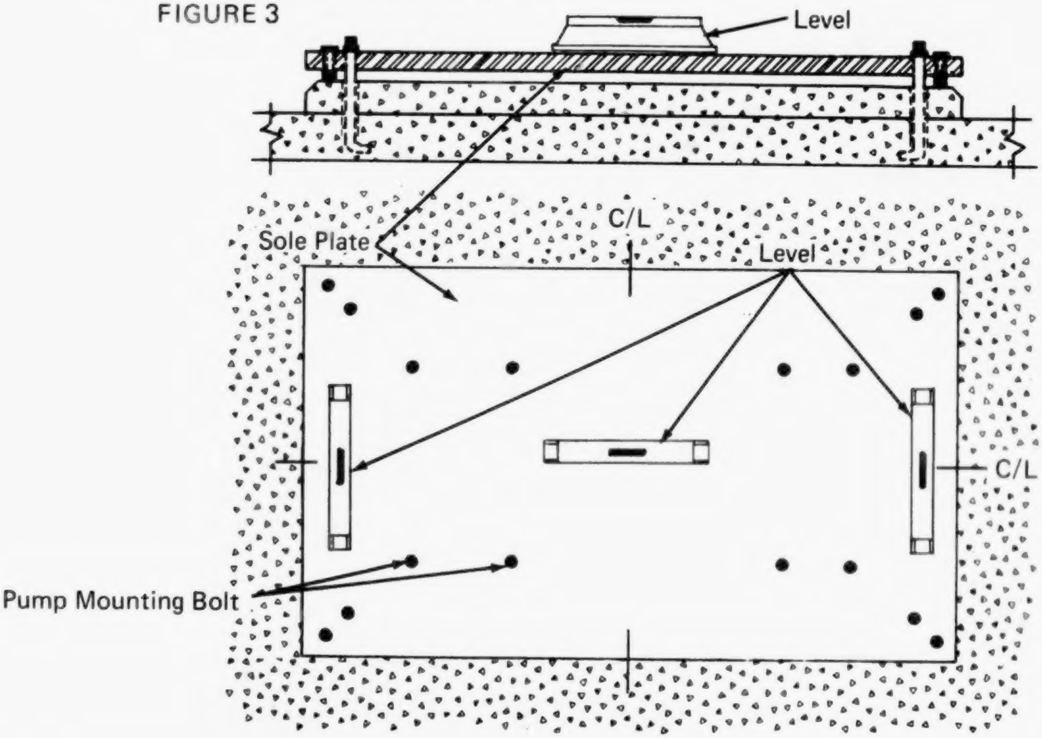
E. Set sole plate (Figure 2)

FIGURE 2


Jack Bolt
Anchor Bolt
C/L
Sole Plate
C/L

F. Align and level sole plate (Figure 3)

FIGURE 3

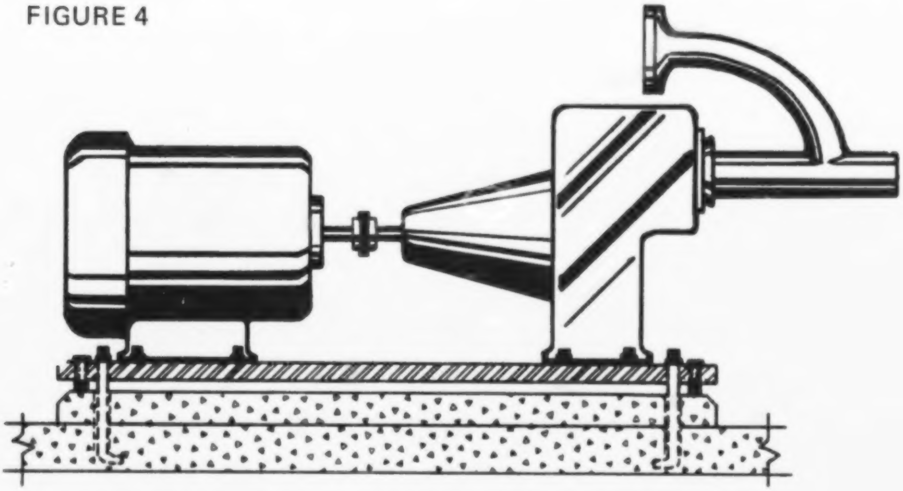

Level
C/L
Sole Plate
Level
C/L
Pump Mounting Bolt

JOB SHEET # 2

G. Set unit on sole plate or anchor bolts (Figure 4)

(NOTE: Sole plates are not always used.)

FIGURE 4



H. Use dimensions from blueprints to center intake and reach proper elevation for discharge

I. Level pump by plumbing intake and discharge flanges of pump

J. Place shims and/or wedges between sole plate or bed plate and concrete; raise or lower until unit is level and has reached proper elevation

K. Tighten anchor bolts

(NOTE: Be sure sole plate is grouted before proceeding.)

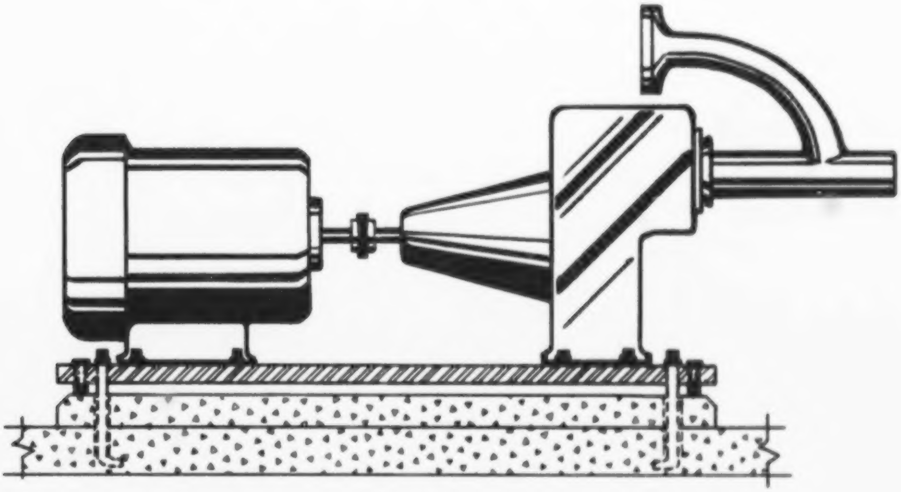
L. Align and level after grouting is completed

(NOTE: Check coupling alignment after unit has been leveled and aligned to center lines. Be sure pump is secured to base plate.)

JOB SHEET #2

M. Make final alignment of motor to pump (Figure 5)

FIGURE 5



N. Check pump for lubrication

O. Install packing

P. Dowel feet to pump base if required

PUMPS
UNIT I

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with pumps to the correct definitions by placing the correct numbers in the blanks provided.

_____a. Mechanical devices that convey liquids against force of gravity

_____b. Proceeding in a direction away from the center of an axis

_____c. Alternating back and forth motion of pistons

_____d. Device used to connect two co-axial shafts together so power can be transmitted from motor shaft to pump shaft

_____e. Turning on an axis

_____f. Vertical distance in feet from supply level to pump center line with pump below supply level

_____g. Vertical distance in feet from pump center line to point of free delivery

_____h. Distance which pump lifts liquid

_____i. Distance liquid must be lifted up to pump

_____j. Thin, flexible material fastened securely around perimeter with center moved back and forth to provide displacing action

_____k. Part of pump that applies high energy force to fluid to supply velocity and momentum

_____l. Amount of misalignment on a rotating shaft that is read by an indicator

1. Total head (head lift)
2. Diaphragm
3. Impeller
4. Pumps
5. Discharge head
6. Centrifugal
7. Rotary
8. Reciprocating
9. Run-out
10. Suction head
11. Coupling
12. Suction lift

2. *List types of pumps.*

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

3. Select from the list below features of centrifugal pumps. Place an "X" in the correct blanks.

_____a. High price

_____b. Simple design

_____c. Very inefficient for large capacities

_____d. Very inefficient for low pressures

_____e. Relatively low cost

_____f. Do not clog when pumping liquids containing foreign matter

_____g. Back and forth motion makes it easier to pump liquids containing foreign matter

4. List types of positive displacement used in reciprocating pumps.

a. ____________________

b. ____________________

c. ____________________

5. Select from the following list elements used in rotary pumps to move liquids. Place an "X" in the correct blanks.

_____a. Water base

_____b. Lobes

_____c. Vanes

_____d. Couplings

_____e. Gears

_____f. Wheels

______g. Pulleys

______h. Cams

6. Describe standard pump ratings in general use.

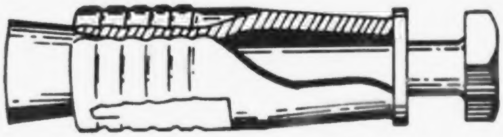
a. Gallons per minute (GPM)--______________________________

____

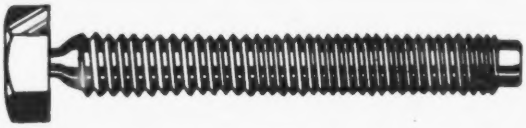
b. Pounds per square inch (PSI)______________________________

____

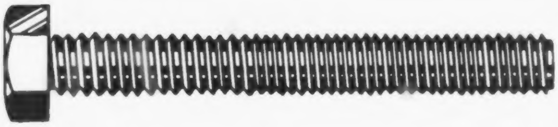
7. Identify types of anchors used for pump installation illustrated below. Place the correct names in the blanks provided.



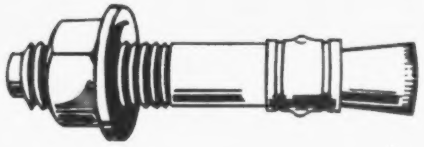
a. ______________________________



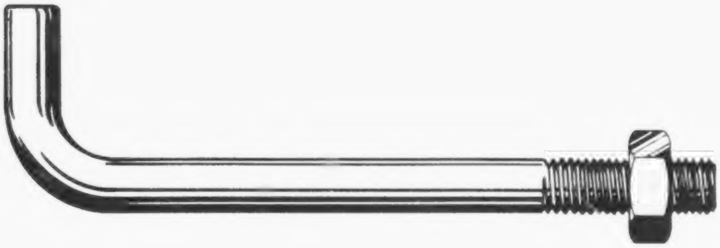
b. ______________________________



c. ______________________________



d. ______________________________



e. ______________________________

8. Arrange in order steps to follow when installing a pump. Place a "1" in front of the first step, a "2" in front of the second step, and so on.

______a. Secure pump

______b. Check anchor bolts for proper length, proper layout, and damage

______c. Align pump discharge and/or intake to center lines on floor or to music wire as reference points

______d. Locate center lines

______e. Proceed with coupling alignment

______f. Level pump

______g. Set pump on anchor bolts

______h. Prepare (clean) foundation, anchor bolts, and sleeves

______i. Install packing

______j. Set and align sole plate using jack bolts and shims or anchor bolts

______k. Dowel feet to pump base if required

______l. Check pump for lubrication

9. Demonstrate the ability to:

   a. Set, align, and level a vertical pump.

   b. Set, align, and level a horizontal pump.

(NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

PUMPS
UNIT I

ANSWERS TO TEST

1. a. 4
   b. 6
   c. 8
   d. 11
   e. 7
   f. 10
   g. 5
   h. 1
   i. 12
   j. 2
   k. 3
   l. 9
2. a. Centrifugal
   b. Reciprocating
   c. Rotary
   d. Propeller
   e. Turbine
   f. Diaphragm
   g. Helical
3. b, e, f
4. a. Piston
   b. Plunger
   c. Diaphragm
5. b, c, e, h
6. a. Volume of liquid delivered by pump
   b. Pressure at which liquid is moved
7. a. Expansion bolt
   b. Jack bolt
   c. Jack bolt

   d. Wedge anchor

   e. Anchor bolt

8. a. 8

   b. 3

   c. 6

   d. 2

   e. 9

   f. 7

   g. 5

   h. 1

   i. 11

   j. 4

   k. 12

   l. 10

9. Performance skills evaluated to the satisfaction of the instructor

COMPRESSORS
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify and install different types of compressors. This knowledge will be evidenced by completion of the job sheet and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with compressors to correct definitions.
2. Distinguish between major types of compressors.
3. List specific types of compressors.
4. Match classifications of compressors to correct operations.
5. Identify types of reciprocating compressors according to cylinder arrangement.
6. Arrange in order steps to follow when installing a compressor.
7. Demonstrate the ability to set, align, and level a compressor.

COMPRESSORS
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide students with objective sheet.

  B. Provide students with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss procedures outlined in job sheet.

  G. Give test.

II. Instructional materials:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Types of Compressors

    2. TM 2--Types of Compressors (Continued)

    3. TM 3--Types of Compressors (Continued)

    4. TM 4--Classifications of Compressors

  D. Job Sheet #1--Set, Align, and Level a Compressor

  E. Test

  F. Answers to test

III. Unit references:

  A. *Construction Millwright I. Training Module*. Houston, Texas: Brown and Root, Inc., n.d.

  B. Nelson, Carl A. *Millwrights' and Mechanics' Guide*. 2nd ed. Indianapolis, Indiana: Howard W. Sams and Co., Inc., 1978.

COMPRESSORS
UNIT II

INFORMATION SHEET

I. Terms and definitions

- A. Air compressor--Equipment that compresses air under pressure greater than that of the atmosphere
- B. Stages (single and multistage)--Number of steps a reciprocating compressor uses to compress air to final pressure
- C. Acting (single and double)--Classification of compressor according to operation
- D. Reciprocating--Alternating back and forth motion of pistons
- E. Dynamic--Force created by rapid turning of rotor blades
- F. Vane--Blade or fin-type object that rotates to cause air to flow or that redirects flow of air
- G. Impeller--Part of compressor that applies high energy force to air to supply velocity and momentum
- H. Axial flow--Relatively constant flow of air through blades mounted on a rotor
- I. Rotor--Part that revolves in a stationary housing

II. Difference between major types of compressors

- A. Positive displacement--Confines air within a closed space and compresses it by reducing the volume of space

  (NOTE: Some are capable of compressing air to comparatively high pressure.)

- B. Dynamic--Accelerates air with rapidly turning rotor blades which tend to slightly raise pressure

III. Specific types of compressors (Transparencies 1-3)

(NOTE: These are only a few of the many specific types.)

- A. Positive displacement
  - 1. Reciprocating (piston)
    - a. Horizontal
    - b. Vertical

INFORMATION SHEET

2. Rotary screw
3. Rotary lobe or impeller
4. Rotary sliding vane
5. Diaphragm

B. Dynamic (centrifugal)

1. Single-stage
2. Axial flow (multistage)

IV. Classifications of compressors according to operations (Transparency 4)

A. Single-stage--Draws in air at atmospheric pressure and compresses it to final pressure in one stroke

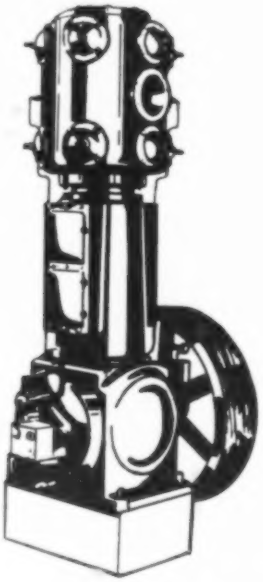
B. Multistage--Draws in air at atmospheric pressure and compresses it to final pressure in two or more strokes

C. Single-acting--Compresses air at only one end of cylinder

D. Double-acting (crosshead)--Compresses air at both ends of cylinder

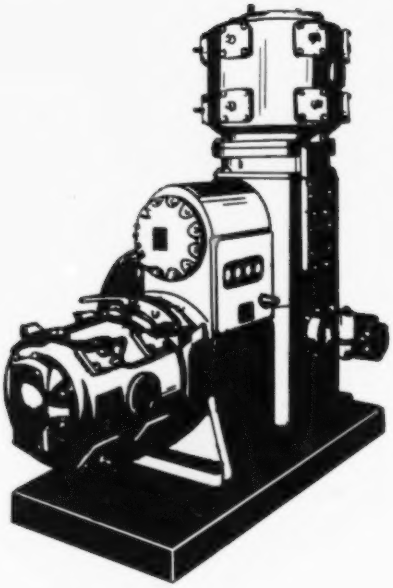
V. Types of reciprocating compressors according to cylinder arrangement

A. Vertical

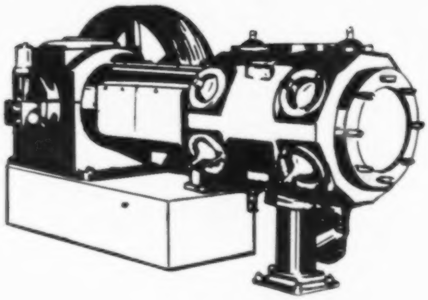


INFORMATION SHEET

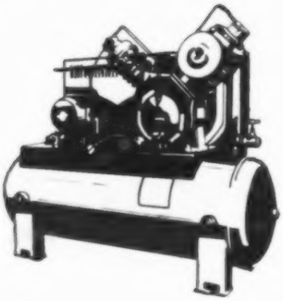
B. Angle



C. Horizontal

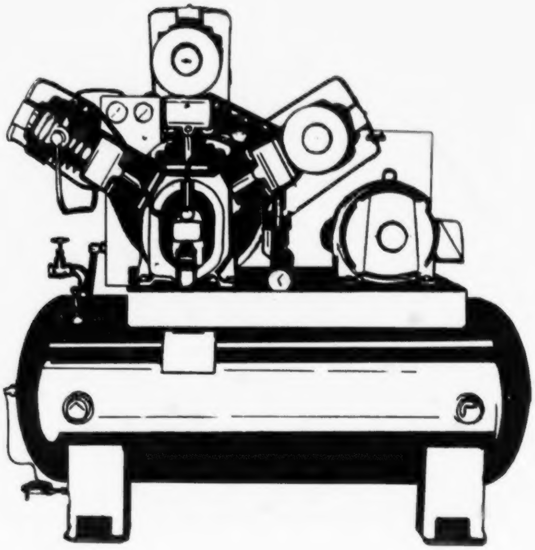


D. V or Y



INFORMATION SHEET

E. W



VI. Steps to follow when installing a compressor

A. Prepare (clean) foundation, anchor bolts, and sleeves

B. Locate and/or establish center lines

C. Check anchor bolts for proper layout, proper length and damage

D. Set compressor on anchor bolts

E. Align compressor using center lines on floor or music wire as reference point

F. Check level and elevation of compressor

G. Level compressor

(NOTE: Compressor must be level and plumb in all directions.)

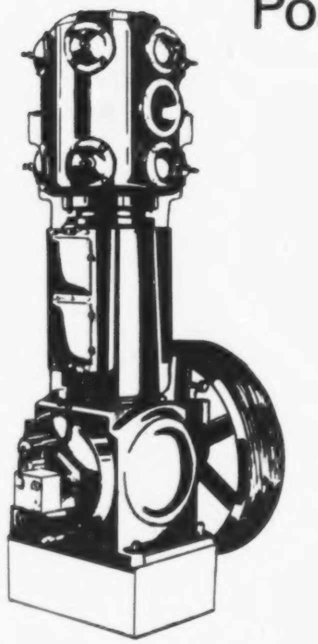
H. Secure compressor

I. Check coupling alignment if used

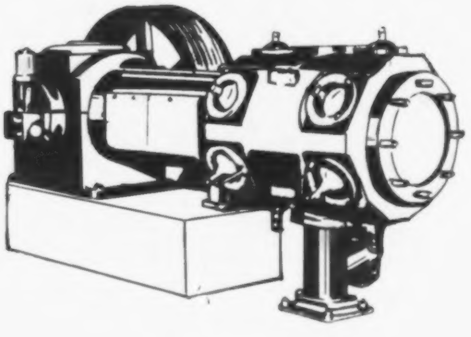
(NOTE: Refer to coupling alignment.)

Types of Compressors

Positive Displacement

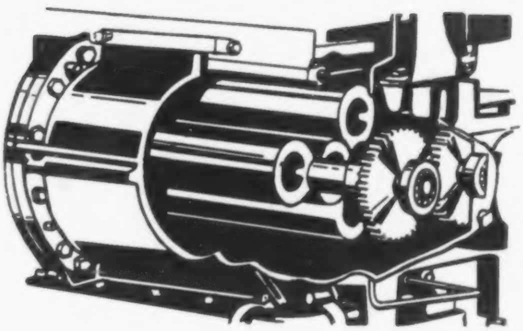


Vertical

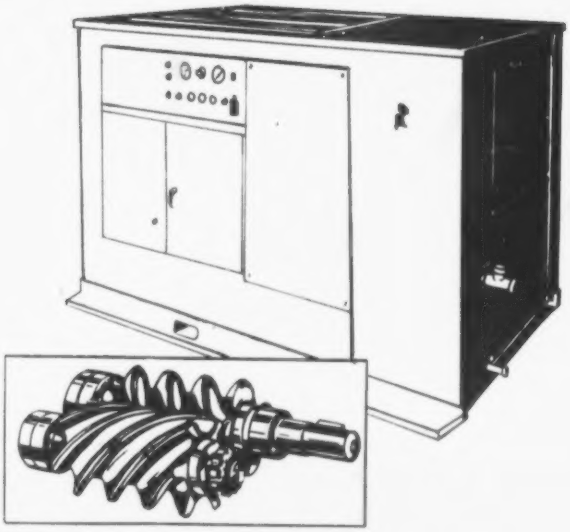


Horizontal

Reciprocating



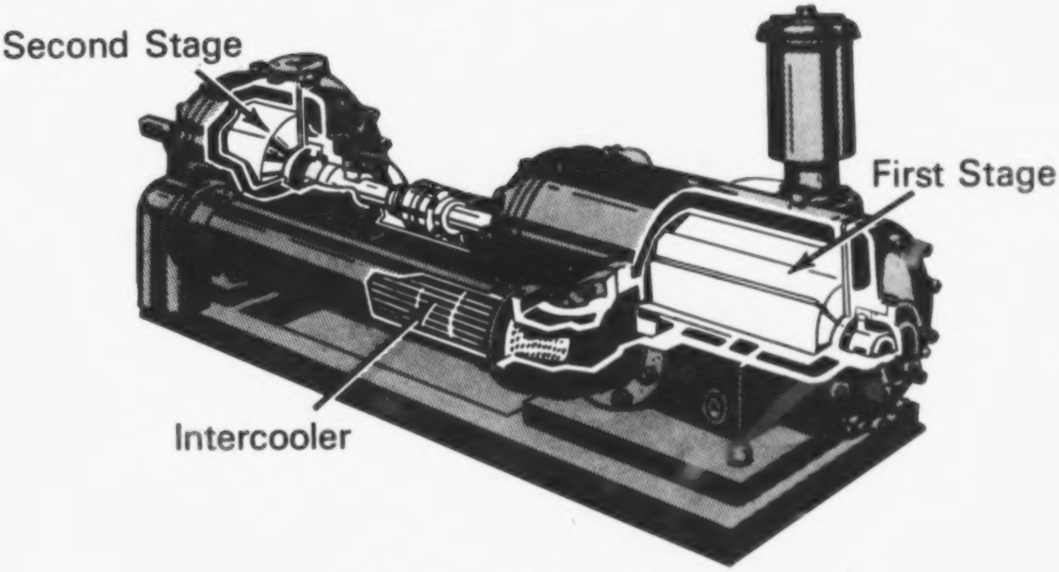
Rotary Lobe or Impeller



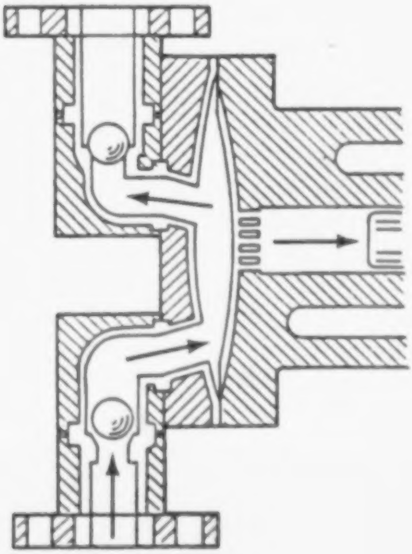
Rotary Screw
Compression Package

Types of Compressors

(Continued)


Second Stage
First Stage
Intercooler

Rotary Sliding Vane

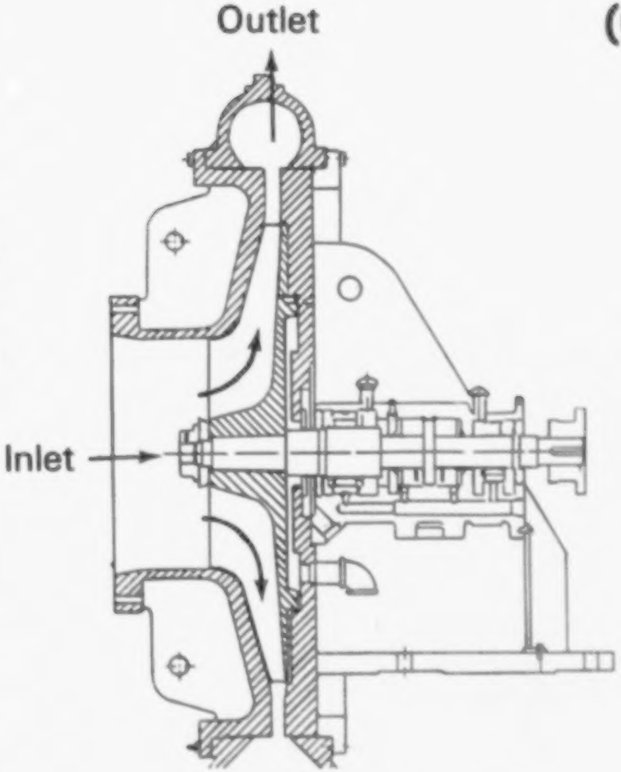


Diaphragm

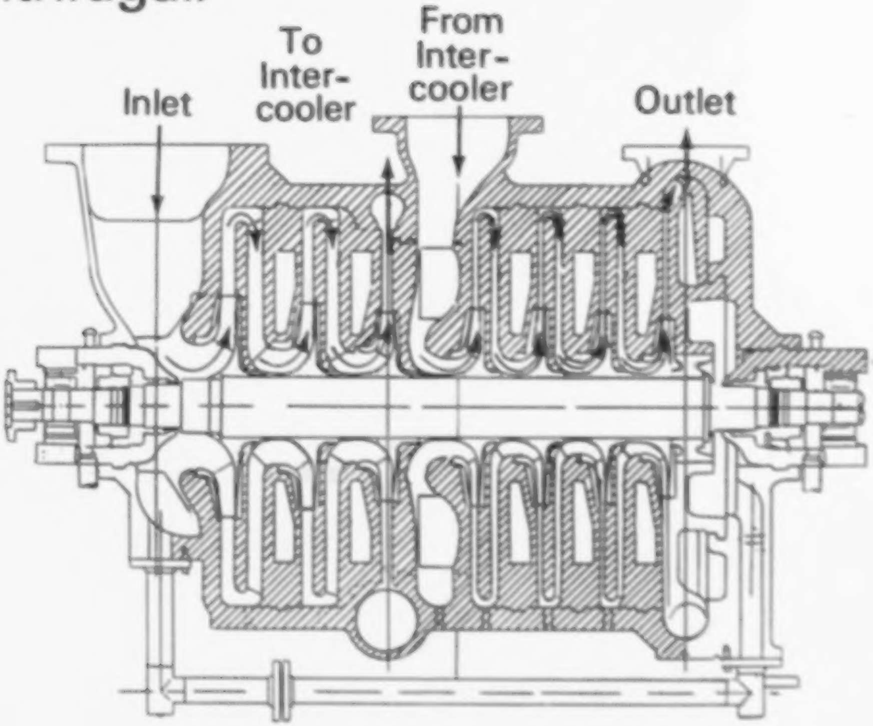
Types of Compressors

(Continued)

Dynamic (Centrifugal)

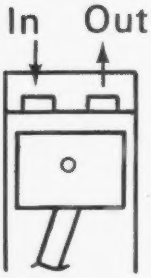

Outlet
Inlet

Single-Stage

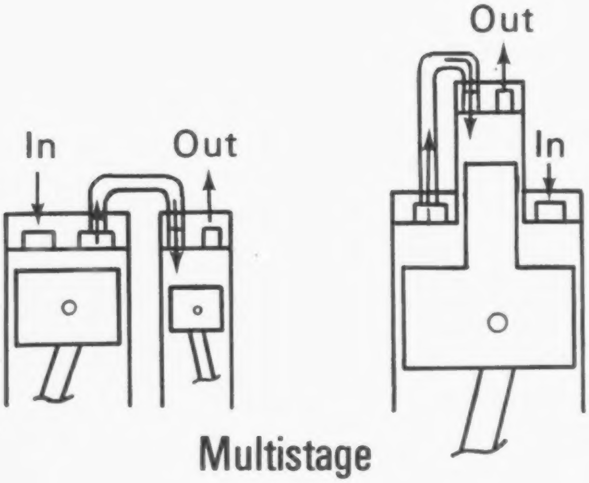

Inlet
To Inter-cooler
From Inter-cooler
Outlet

Axial Flow (Multistage)

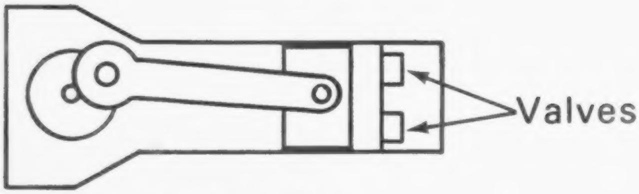
Classifications of Compressors



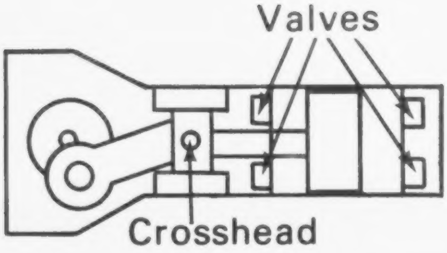
Single-Stage


In
Out
Out
In

Multistage



Single-Acting


Valves
Crosshead

Double-Acting (Crosshead)

COMPRESSORS
UNIT II

JOB SHEET #1--SET, ALIGN, AND LEVEL A COMPRESSOR

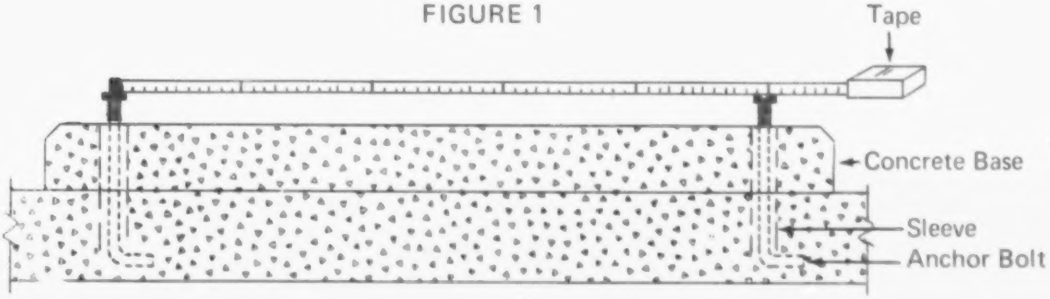
I. Tools and materials

- A. Broom or brush
- B. Steel tape, 100'
- C. Lifting device
- D. Precision level
- E. Assorted wrenches
- F. Plumb bob
- G. Jack bolts
- H. Shims, assorted sizes and thicknesses
- I. Sole plate (if applicable)
- J. Compressor unit
- K. Chalk line and/or music wire

II. Procedure

- A. Prepare (clean) foundation, anchor bolts, and sleeves prior to installation
- B. Locate and/or establish center lines
- C. Check anchor bolts for proper layout, proper length, and damage (Figure 1)

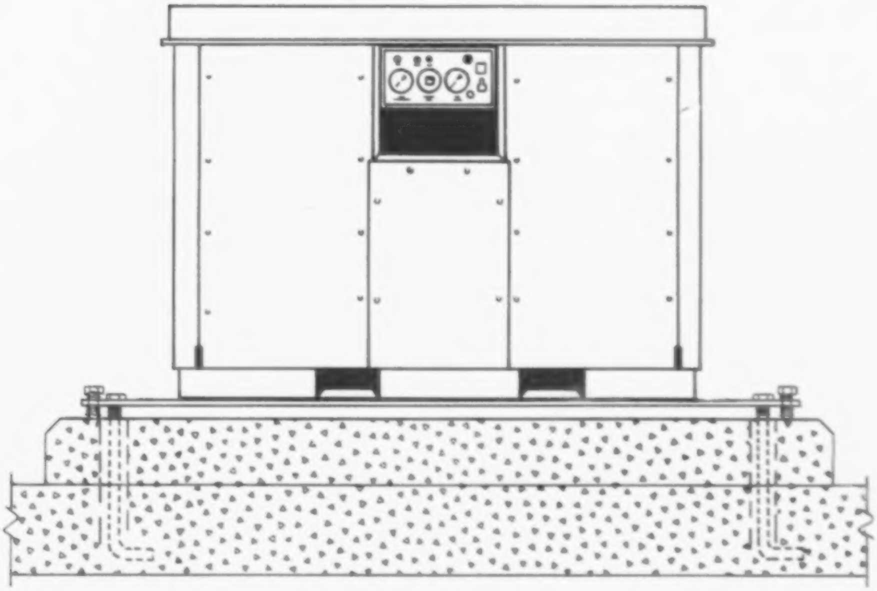
FIGURE 1



JOB SHEET #1

D. Install compressor (Figure 2)

FIGURE 2



E. Align compressor to center lines by dropping plumb bob from center line of compressor unit to center lines already established

F. Place level across machined surfaces of compressor or compressor frame and check

G. Turn level 90° and check

H. Level compressor by adjusting jack bolts and shim under base, if necessary

I. Secure compressor

J. Align coupling or sheaves (if belt driven)

K. Check compressor for lubrication

L. Dowel feet to base if required

COMPRESSORS
UNIT II

TEST

NAME ________________________ SCORE ______________

1. Match terms associated with compressors to the correct definitions. Place the appropriate numbers in the blanks provided.

______a. Equipment that compresses air under pressure greater than that of the atmosphere

______b. Number of steps a reciprocating compressor uses to compress air to final pressure

______c. Classification of compressor according to operation

______d. Alternating back and forth motion of pistons

______e. Force created by rapid turning of rotor blades

______f. Blade or fin-type object that rotates to cause air to flow or that redirects flow of air

______g. Part of compressor that applies high energy force to air to supply velocity and momentum

______h. Relatively constant flow of air through blades mounted on a rotor

______i. Part that revolves in a stationary housing

1. Impeller
2. Reciprocating
3. Axial flow
4. Air compressor
5. Acting (single and double)
6. Rotor
7. Stages (single and multistage)
8. Dynamic
9. Vane

2. Distinguish between major types of compressors. Place a "P" in the blank before positive displacement and a "D" in the blank before dynamic.

______a. Accelerates air with rapidly turning rotor blades which tend to slightly raise pressure

______b. Confines air within a closed space and compresses it by reducing the volume of space

3. List specific types of compressors in the blanks provided below.
   a. Positive displacement
      1) ______________________________
         a. ______________________________
         b. ______________________________
      2) ______________________________
      3) ______________________________
      4) ______________________________
      5) ______________________________
   b. Dynamic
      1) ______________________________
      2) ______________________________

4. Match classifications of compressors to correct operations by placing the correct numbers in the blanks provided.

______a. Draws in air at atmospheric pressure and compresses it to final pressure in one stroke

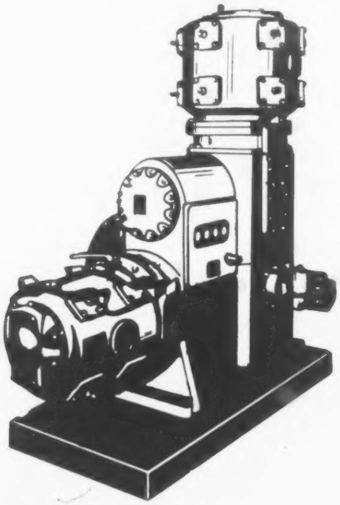
______b. Compresses air at both ends of a cylinder

______c. Draws in air at atmospheric pressure and compresses it to final pressure in two or more strokes

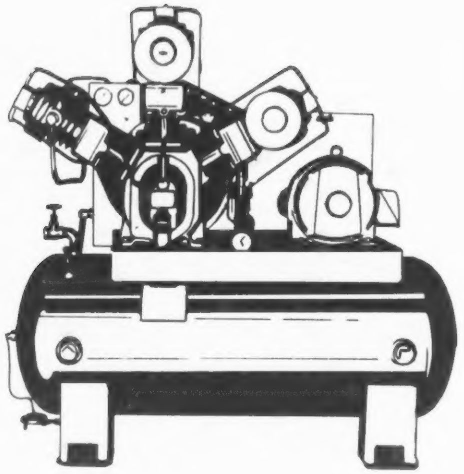
______d. Compresses air at only one end of cylinder

1. Single-acting
2. Single-stage
3. Double-acting (crosshead)
4. Multistage

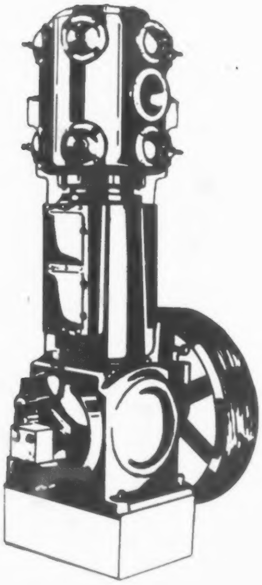
5. Identify the types of reciprocating compressors illustrated below according to cylinder arrangement. Write the correct names in the blanks provided.



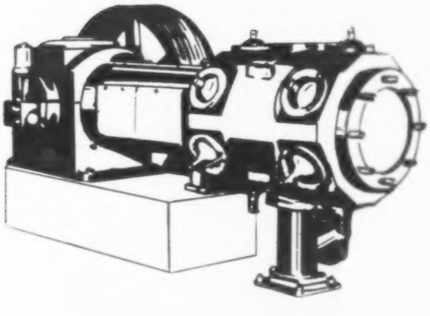
a. ______________________________



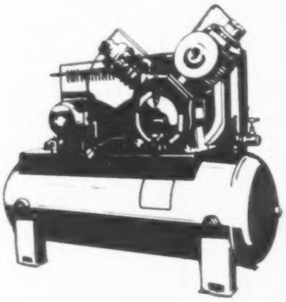
b. ______________________________



c. ______________________________



d. ______________________________



e. ______________________________

6. Arrange in order steps to follow when installing a compressor. Place a "1" in the blank before the first step, a "2" before the second step, and so on.

______a. Prepare (clean) foundation, anchor bolts, and sleeves

______b. Align compressor using centerlines on floor or music wire as reference point

______c. Level compressor

______d. Set compressor on anchor bolts

______e. Secure compressor

______f. Locate and/or establish centerlines

______g. Check anchor bolts for proper layout, proper length, and damage

______h. Check coupling alignment if used

______i. Check level and elevation of compressor

7. Demonstrate the ability to set, align, and level a compressor.

   (NOTE: If this activity has not been accomplished prior to the test, ask your instructor when it should be completed.)

COMPRESSORS
UNIT II

ANSWERS TO TEST

1. a. 4
   b. 7
   c. 5
   d. 2
   e. 8
   f. 9
   g. 1
   h. 3
   i. 6
2. a. D
   b. P
3. a. Positive displacement
      1) Reciprocating (piston)
         a. Horizontal
         b. Vertical
      2) Rotary screw
      3) Rotary lobe or impeller
      4) Rotary sliding vane
      5) Diaphragm
   b. Dynamic (centrifugal)
      1) Single-stage
      2) Axial flow (multistage)
4. a. 2
   b. 3
   c. 4
   d. 1

5. a. Angle
   b. W
   c. Vertical
   d. Horizontal
   e. V or Y
6. a. 1
   b. 5
   c. 7
   d. 4
   e. 8
   f. 2
   g. 3
   h. 9
   i. 6
7. Performance skills evaluated to the satisfaction of the instructor

STEAM TURBINES
UNIT III

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify major components of a steam turbine and illustrate the path of steam in a turbine. This knowledge will be evidenced by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with steam turbines to the correct definitions.
2. Name major sections of a steam turbine.
3. Match components of a steam turbine to the correct definitions.
4. List types of steam turbines.
5. Match purposes of turbine steam utilization plans to the correct uses.
6. Arrange in order the path of steam in a steam turbine.
7. Illustrate the path of steam in a steam turbine.

STEAM TURBINES
UNIT III

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information sheet.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Discuss installation of a steam turbine.

   (NOTE: Installation of a steam turbine is a very long-range and complex project; therefore, it would not be practical to use class time to demonstrate actual installation.)

   G. Give test.

II. Instructional materials:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Steam Turbine

      2. TM 2--Components of a Steam Turbine

      3. TM 3--Path of Steam in a Steam Turbine

   D. Test

   E. Answers to test

III. Unit references:

   A. Glenn, Harold T. *Exploring Power Mechanics.* Rev. ed. Peoria, Illinois Chas. A. Bennett Co., Inc., 1967.

   B. Duffy, Joseph W. *Power: Prime Mover of Technology*. 2nd ed. Bloomington, Illinois: McKnight and McKnight Publishing Company, 1972.

STEAM TURBINES
UNIT III

INFORMATION SHEET

I. Terms and definitions

   A. Steam turbine--Machine with central rotating spindle with a series of vanes or blades actuated by the reaction and/or impulse of pressurized steam current which provides power to operate equipment

   B. Diaphragm--Usually, a thin flexible disc that acts as a barricade

   C. Nozzle--Projecting, tapered vent used to speed or direct a flow of water or steam

   D. Impulse--Tremendous speed or force created by steam

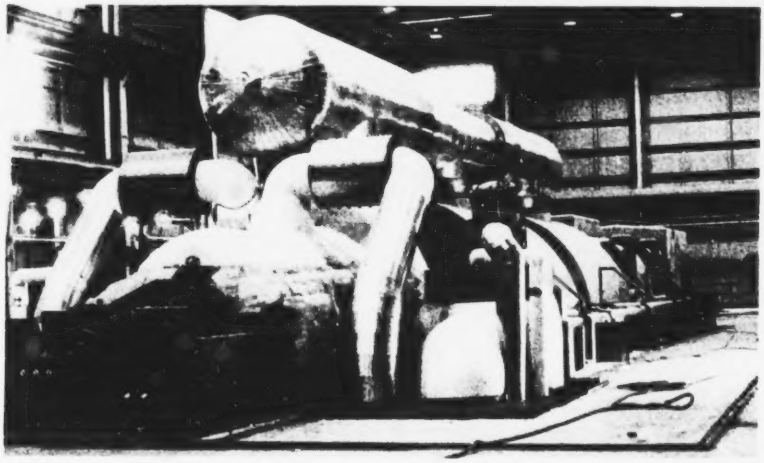
   E. Reaction--Increased volume of steam created by rotor blades that have reduced the pressure

   F. Compound--Two or more separate turbines in separate housings

II. Major sections of a steam turbine (Transparency 1)

   A. High pressure

   B. Low pressure



INFORMATION SHEET

III. Components of a steam turbine (Transparency 2)

(NOTE: The low pressure section has the same major components as the high pressure section, but it is normally made of much lighter material since the low pressure section operates with cooler steam and lower pressure.)

A. Nozzle box--Usually located in center of turbine where steam enters unit

B. High pressure diaphragm--Located inside high pressure inner shell; directs steam toward rotor blades causing them to rotate

C. Rotor--Shaft with blade-like vanes that extends through turbine and is rotated by steam pressure

D. High pressure inner shell--Housing inside outer shell of a high pressure turbine that contains all parts of the unit and helps to confine heat and pressure inside

E. Packing heads (labyrinth packing)--Seal that prevents steam from escaping around rotor or shaft; usually located at each end of high pressure outer shell

F. Bearings--Support mechanisms usually located at each end of rotor

G. Oil deflectors--Act as oil seals on each side of bearing

H. High pressure outer shell--Very heavy steel outer housing that controls steam heat

I. Crossover--Carries steam from high pressure section to low pressure section

IV. Types of steam turbines

A. Impulse

B. Reaction

C. Compound

V. Purposes of turbine steam utilization plans

A. Reheat cycle--Partially expands steam, then reheats it and passes it through again

B. Noncondensing unit--Exhausts steam and does not return it to boiler

C. Regenerative cycle--Condenses used steam with a condenser

INFORMATION SHEET

D. Back pressure unit--Sends used steam to another unit which operates at a lower pressure

E. Extraction unit--Arranged to bleed some of the steam at different points for operation of other equipment

VI. Path of steam in a steam turbine

A. Enters machine on high pressure section at the nozzle box

B. Nozzle box directs half of steam to diaphragms on one end and half to diaphragms on opposite end

C. When steam hits diaphragms, their blades redirect steam from straight path to a circular motion

D. While in circular motion, steam hits vanes on rotor causing them to rotate

E. After passing through high pressure section, steam enters crossover and is carried to low pressure section

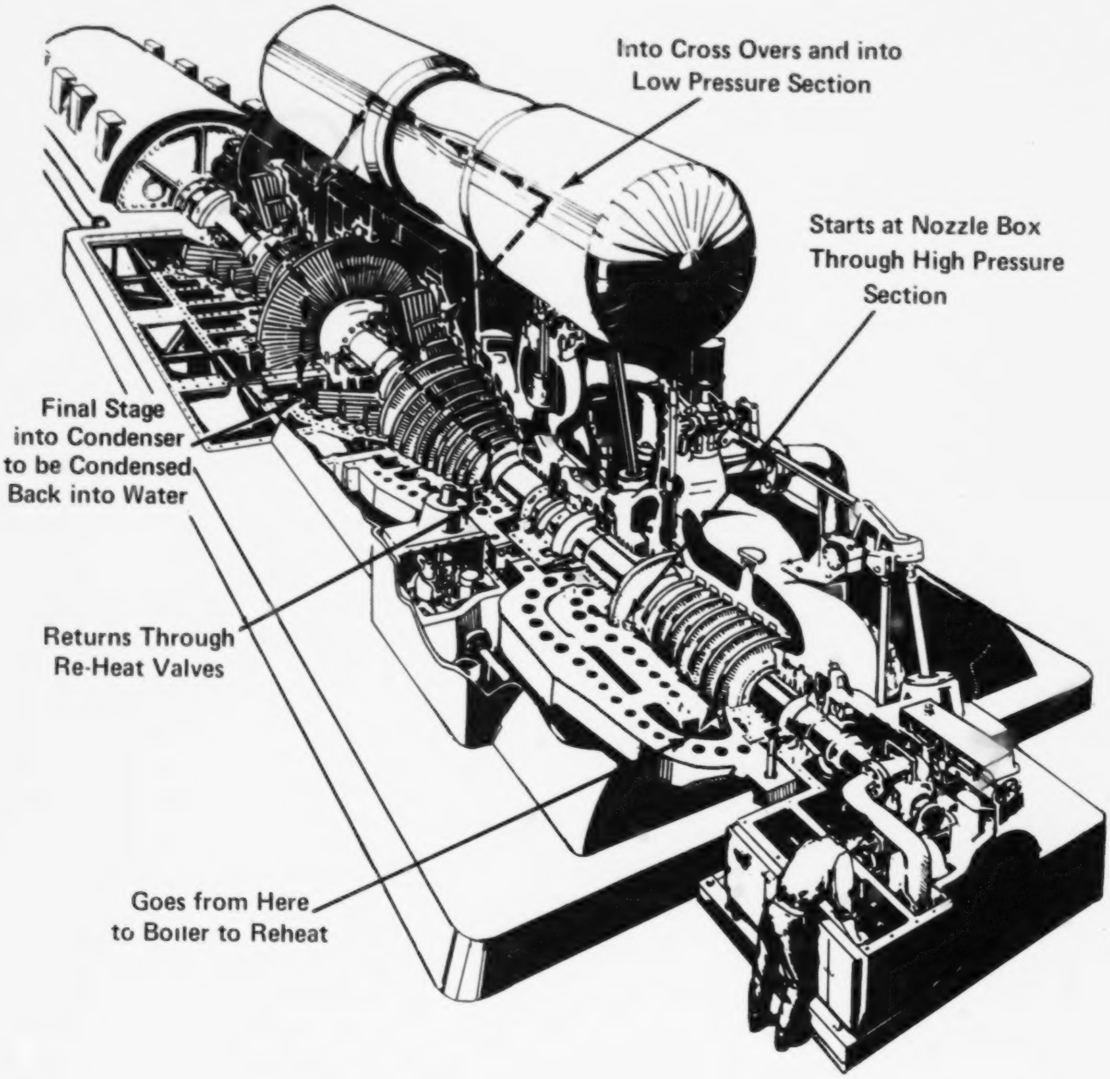
F. From low pressure section, steam follows same route through nozzle box to diaphragms and finally to low pressure rotor

G. After passing through low pressure section, steam travels through condenser where it is condensed back to water and pumped back to boiler

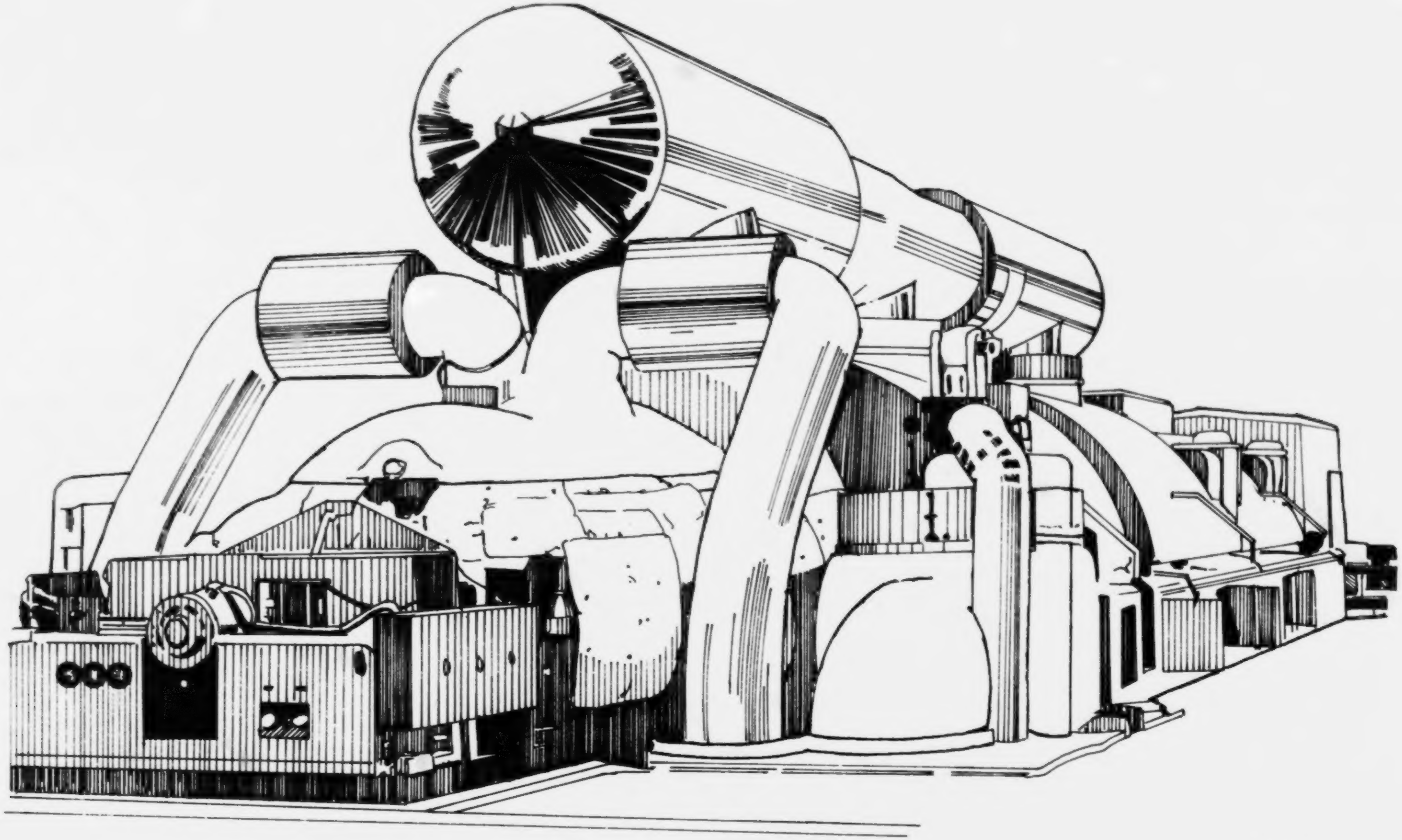
H. At boiler it is reheated and recirculated back through the same channels

INFORMATION SHEET

VII. Path of steam in the steam turbine (Transparency 3)


Into Cross Overs and into Low Pressure Section
Starts at Nozzle Box Through High Pressure Section
Final Stage into Condenser to be Condensed Back into Water
Returns Through Re-Heat Valves
Goes from Here to Boiler to Reheat

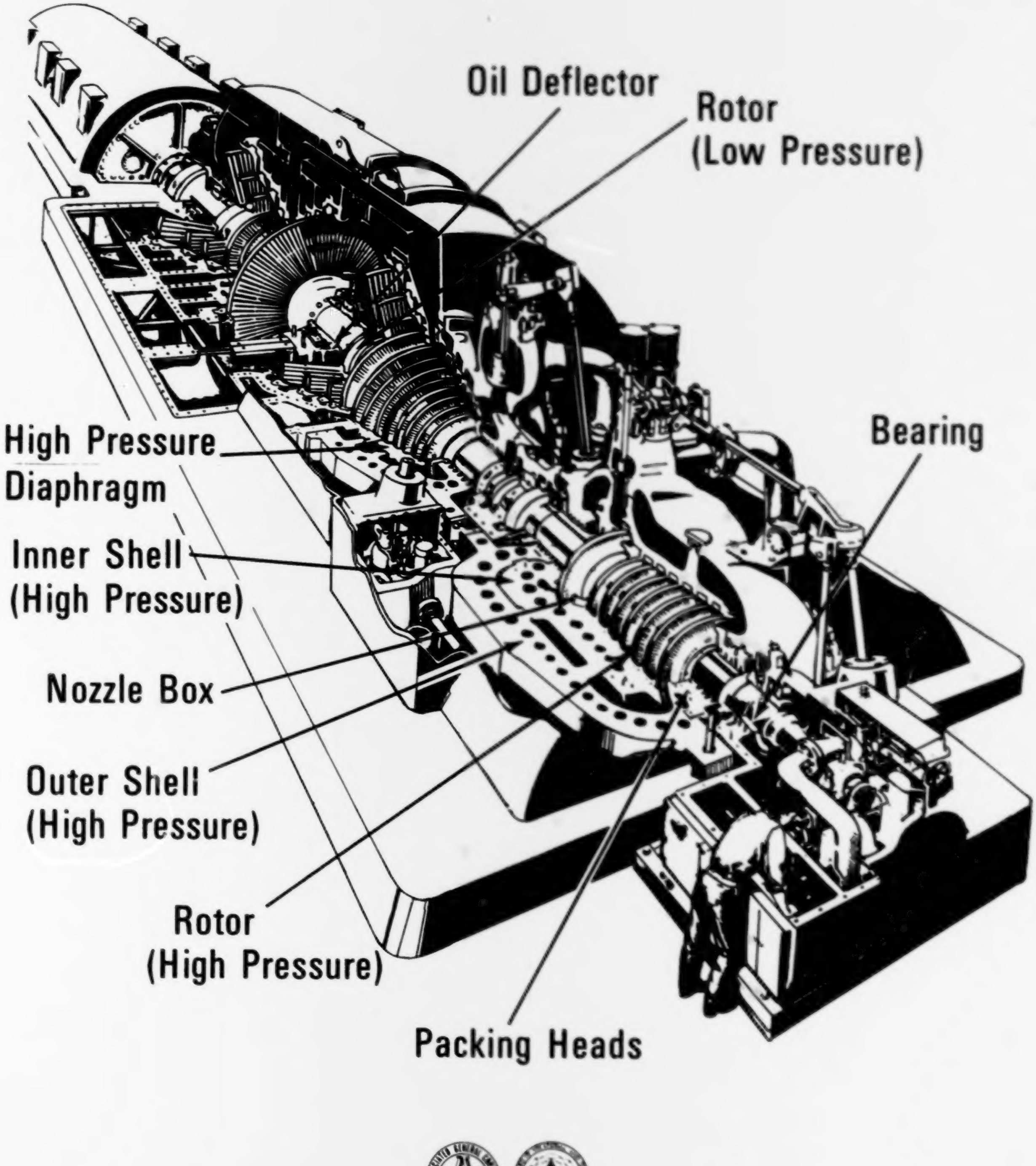
Steam Turbine



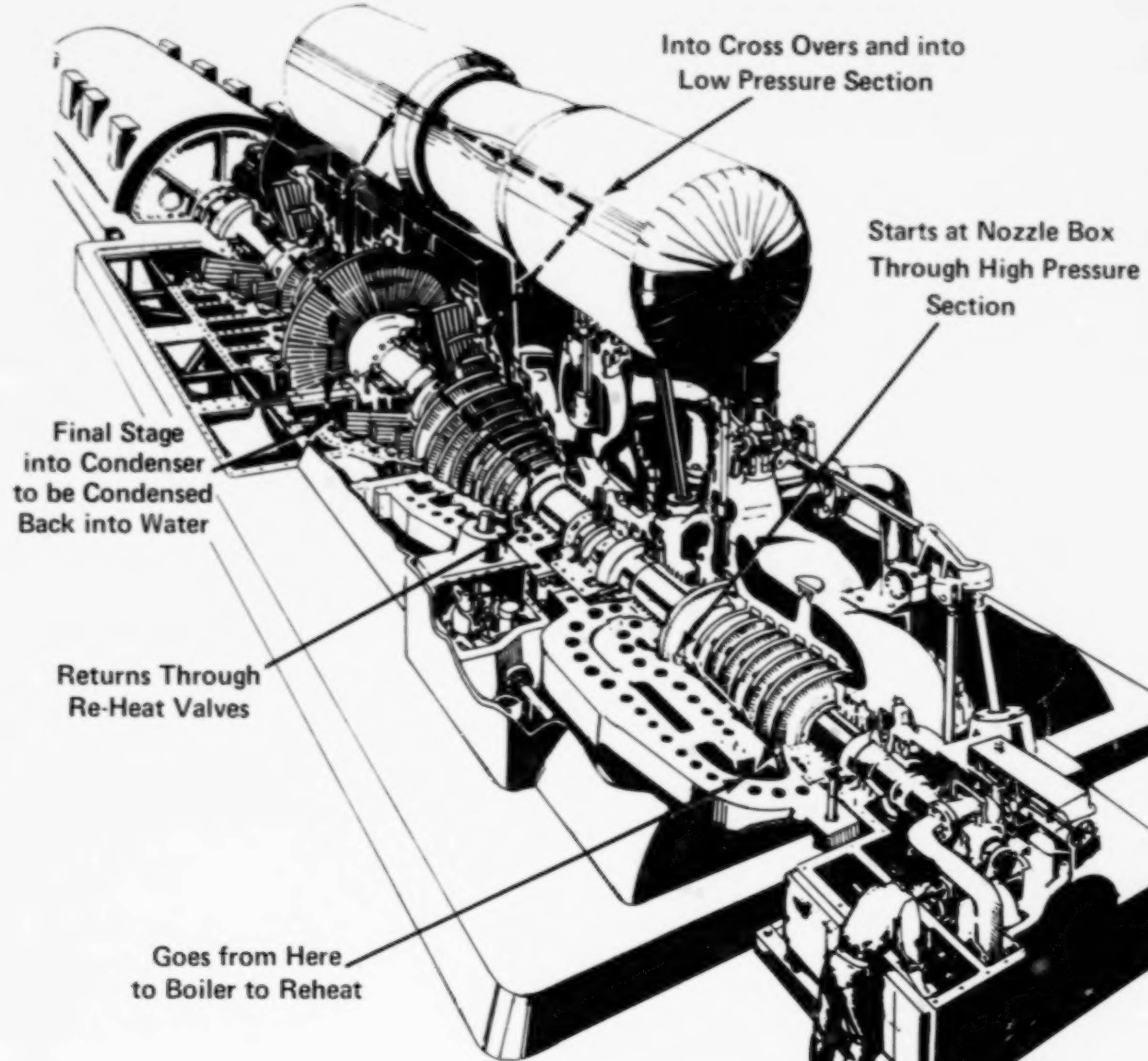
TM 1

MW - 75-1

Components of a Steam Turbine


Oil Deflector
Rotor (Low Pressure)
Bearing
High Pressure Diaphragm
Inner Shell (High Pressure)
Nozzle Box
Outer Shell (High Pressure)
Rotor (High Pressure)
Packing Heads

Path of Steam in a Steam Turbine


Into Cross Overs and into Low Pressure Section
Starts at Nozzle Box Through High Pressure Section
Final Stage into Condenser to be Condensed Back into Water
Returns Through Re-Heat Valves
Goes from Here to Boiler to Reheat

STEAM TURBINES
UNIT III

TEST

NAME________________________________ SCORE______________

1. Match terms associated with steam turbines to the correct definitions by placing the correct numbers in the blanks provided.

______a. Machine with central rotating spindle with a series of vanes or blades actuated by the reaction and/or impulse of pressurized steam current which provides power to operate equipment

______b. Usually, a thin flexible disk that acts as a barricade

______c. Projecting, tapered vent used to speed or direct a flow of water or steam

______d. Tremendous speed or force created by steam

______e. Increased volume of steam created by rotor blades that have reduced the pressure

______f. Two or more separate turbines in separate housings

1. Nozzle
2. Compound
3. Impulse
4. Steam turbine
5. Reaction
6. Diaphragm

2. Name major sections of a steam turbine.

a. ____

b. ____

3. Match components of a steam turbine to the correct definitions. Place the correct numbers in the blanks provided.

______a. Usually located in center of turbine where steam enters unit

______b. Located inside high pressure inner shell; directs steam toward rotor blades causing them to rotate

______c. Shaft with blade-like vanes that extends through turbine and is rotated by steam pressure

______d. Housing inside outer shell of a high pressure turbine that contains all parts of the unit and helps to confine heat and pressure inside

______e. Seal that prevents steam from escaping around rotor or shaft; usually located at each end of high pressure outer shell

______f. Support mechanisms usually located at each end of rotor

______g. Act as oil seals on each side of bearing

______h. Very heavy steel outer housing that controls steam heat

______i. Carries steam from high pressure section to low pressure section

1. Rotor
2. Bearings
3. Crossover
4. High pressure outer shell
5. Nozzle box
6. Oil deflectors
7. High pressure inner shell
8. High pressure diaphragm
9. Packing heads (labyrinth packing)

4. List types of steam turbines.

a. ____

b. ____

c. ____

5. Match purposes of turbine steam utilization plans to the correct uses. Place the correct numbers in the blanks provided.

______a. Partially expands steam, then reheats it and passes it through again

______b. Exhausts steam and does not return it to boiler

______c. Condenses used steam with a condenser

______d. Sends used steam to another unit which operates at a lower pressure

______e. Arranged to bleed some of the steam at different points for operation of other equipment

1. Noncondensing unit
2. Back pressure unit
3. Extraction unit
4. Reheat cycle
5. Regenerative cycle

6. Arrange in order the path of steam in a steam turbine. Place a "1" before the first step, a "2" before the second, and so on.

    ______a. While in circular motion, steam hits vanes on rotor causing them to rotate

    ______b. At boiler it is reheated and recirculated back through the same channels

    ______c. Nozzle box directs half of steam to diaphragms on one end and half to diaphragms on opposite end

    ______d. After passing through high pressure section, steam enters crossover and is carried to low pressure section

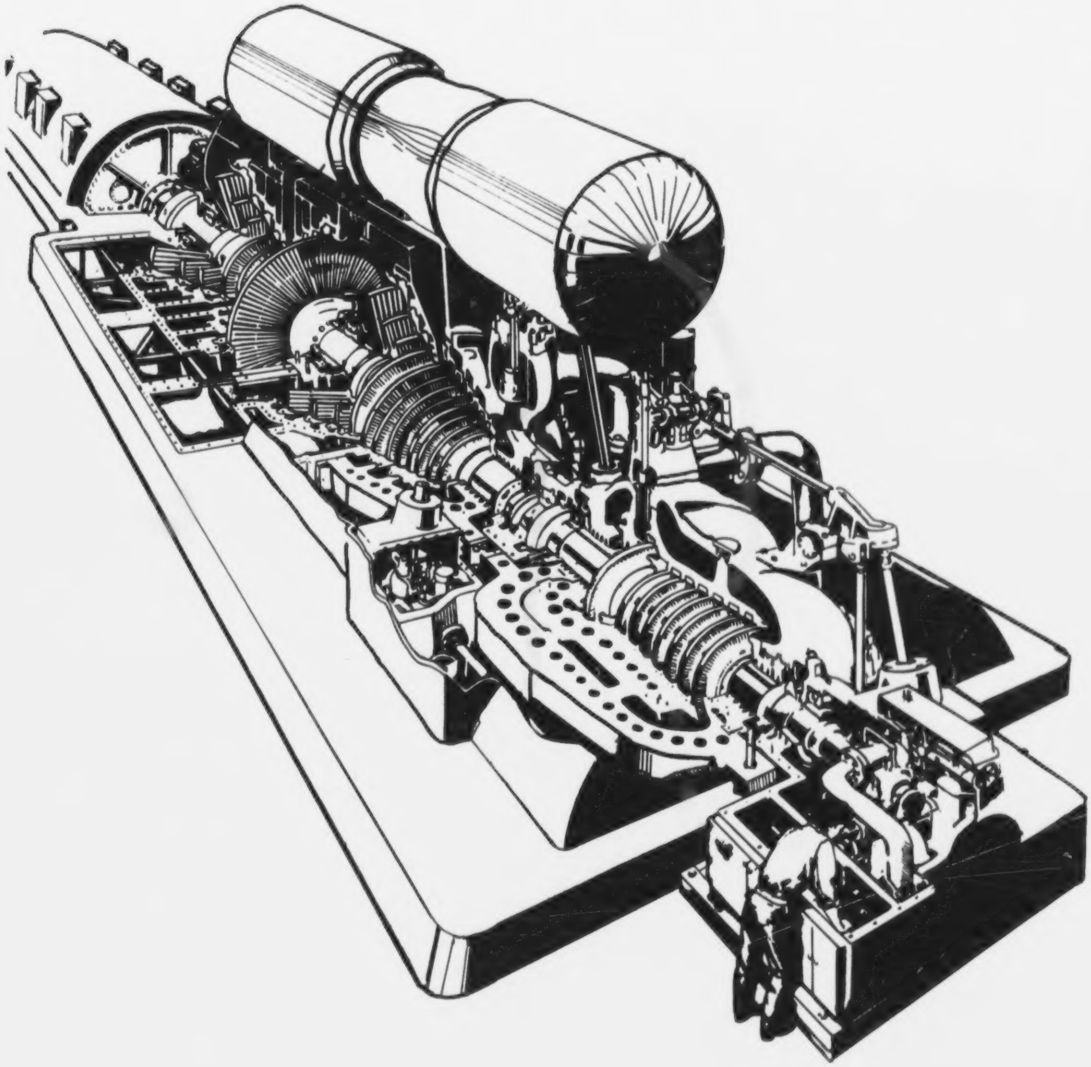
    ______e. Enters machine on high pressure section at the nozzle box

    ______f. After passing through low pressure section, steam travels through condenser where it is condensed back to water and pumped back to boiler

    ______g. When steam hits diaphragms, their blades redirect steam from straight path to a circular motion

    ______h. From low pressure section, steam follows same route through nozzle box to diaphragms and finally to low pressure rotor

7. Illustrate the path of steam in a steam turbine.



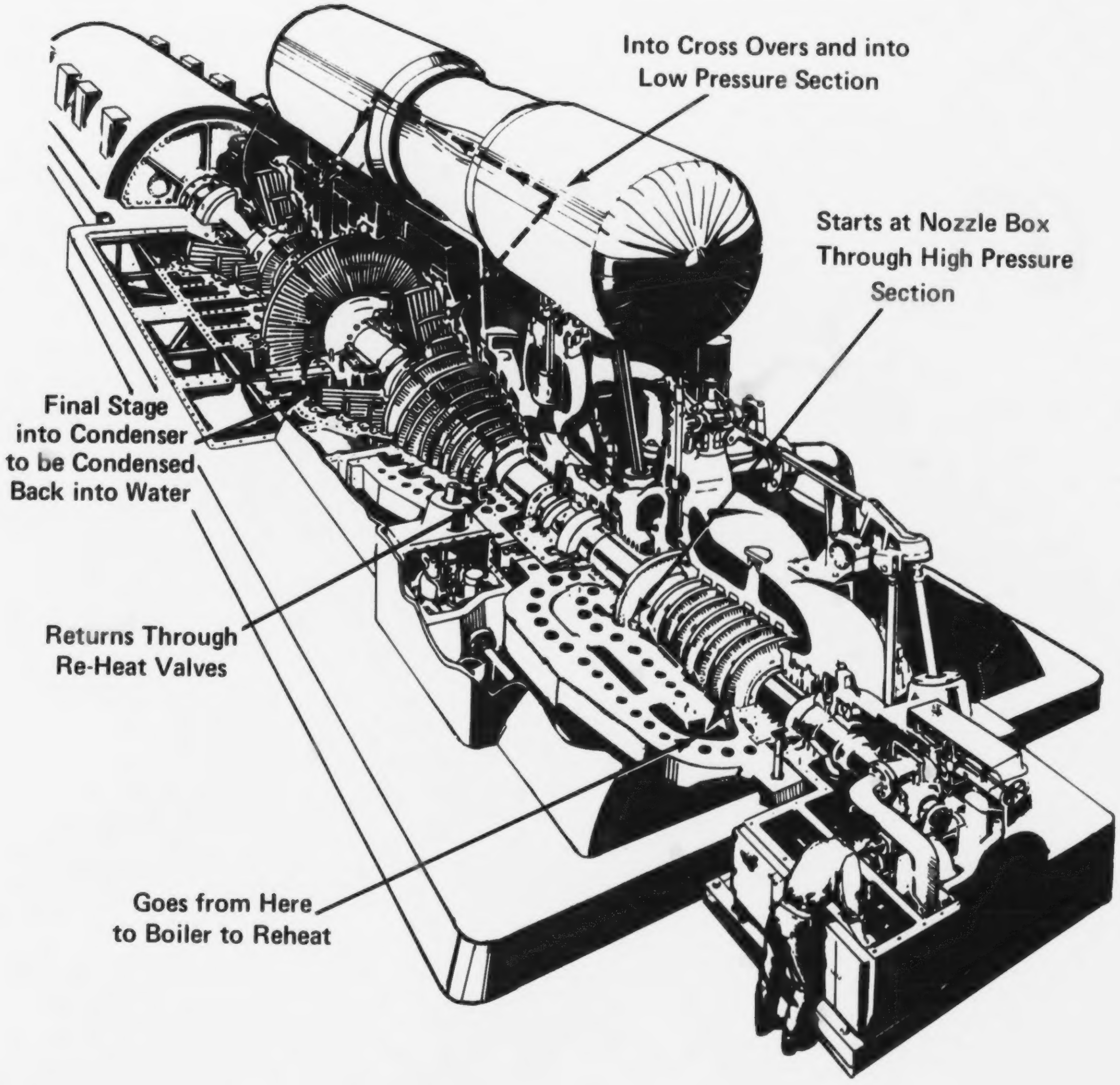
STEAM TURBINES
UNIT III

ANSWERS TO TEST

1. a. 4
   b. 6
   c. 1
   d. 3
   e. 5
   f. 2
2. a. High pressure
   b. Low pressure
3. a. 5
   b. 8
   c. 1
   d. 7
   e. 9
   f. 2
   g. 6
   h. 4
   i. 3
4. a. Impulse
   b. Reaction
   c. Compound
5. a. 4
   b. 1
   c. 5
   d. 2
   e. 3

6. a. 4
   b. 8
   c. 2
   d. 5
   e. 1
   f. 7
   g. 3
   h. 6

7.


Into Cross Overs and into Low Pressure Section
Starts at Nozzle Box Through High Pressure Section
Final Stage into Condenser to be Condensed Back into Water
Returns Through Re-Heat Valves
Goes from Here to Boiler to Reheat

CONVEYORS AND SUPPORT STRUCTURES
UNIT IV

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify different types of conveyors and their components and install a conveyor. This knowledge will be evidenced by completion of the job sheet and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with conveyors and support structures to the correct definitions.
2. Identify basic types of conveyors.
3. Select from a list specific types of conveyors.
4. Identify symbols for a typical conveyor layout.
5. Identify parts of a typical conveyor.
6. Identify parts of an in-floor conveyor system.
7. Distinguish between the typical flow detail for up or down service.
8. Identify components of a conveyor system.
9. List items to check before start-up.
10. List types of support structures for conveyors.
11. Demonstrate the ability to install conveyor and components using basic steps.

CONVEYORS AND SUPPORT STRUCTURES
UNIT IV

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide students with objective sheet.

  B. Provide students with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss procedures outlined in job sheet.

  G. Give test.

II. Instructional materials:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Typical Roller Conveyor Layout
    2. TM 2--Typical Overhead Conveyor Layout
    3. TM 3--Symbols for a Typical Overhead Conveyor Layout
    4. TM 4--Types of Support Structures
    5. TM 5--Types of Support Structures (Continued)
    6. TM 6--Types of Support Structures (Continued)
    7. TM 7--Types of Support Structures (Continued)

  D. Job Sheet #1--Install Conveyor and Components Using Basic Steps

  E. Test

  F. Answers to test

III. Unit references:

A. *Link-Belt Catalog 1050*. Indianapolis, Indiana: Link-Belt Co., 1965.

B. *Rapistan Material Handling Equipment*. Grand Rapids, Michigan: Rapistan Inc., 1975.

C. Headquarters, Department of the Army. *Department of the Army Technical Manual: Rigging*. TM5-725. Washington, D.C.: U.S. Government Printing Office, 1968.

CONVEYORS AND SUPPORT STRUCTURES
UNIT IV

INFORMATION SHEET

I. Terms and definitions

  A. Conveyors--Equipment designed to move materials vertically and horizontally from one point to another

  B. In-floor (tow-line) conveyor--System with power transmitted by a fixed-speed endless chain moving through a steel trough which, at intervals, has connectors that connect to the carts

  C. Live roller--Type of conveyor in which power is transmitted to only these rollers

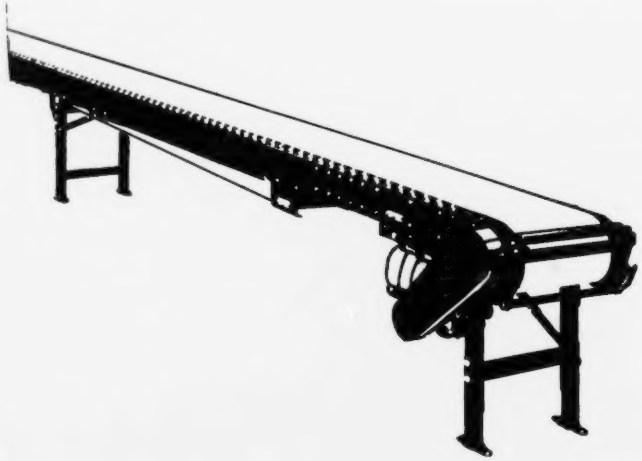
  D. Dead roller (gravity type)--Roller without power transmitted to it

  E. Trolley--Type of overhead conveyor

  F. Support structures--Legs and/or hangers that support conveyors

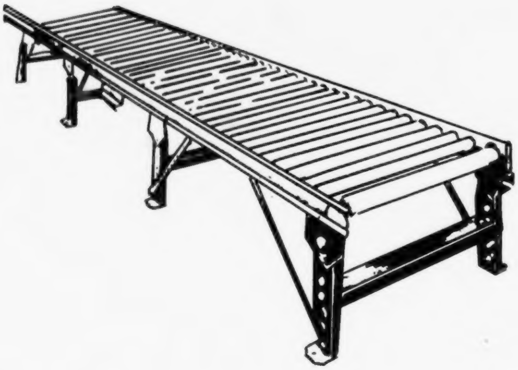
II. Basic types of conveyors

  A. Belt

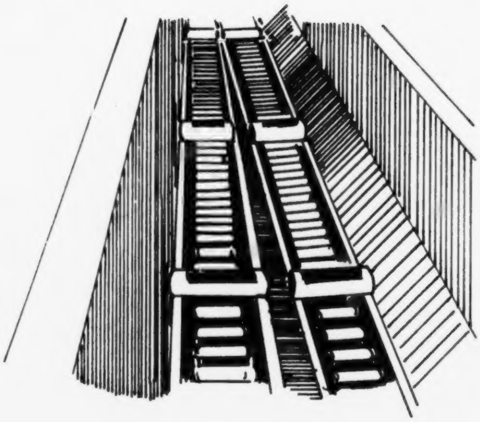


INFORMATION SHEET

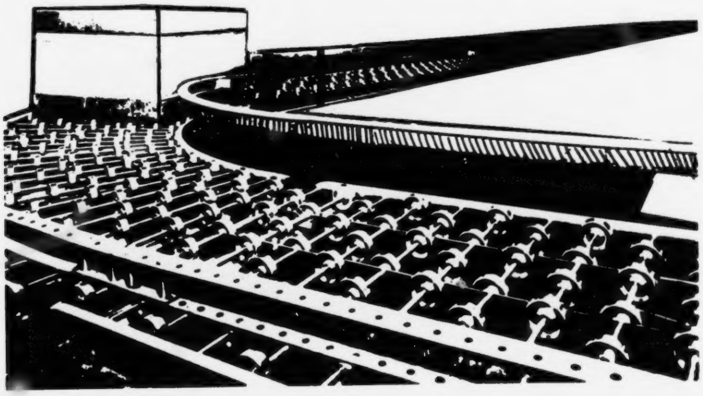
B. Roller



C. Chain

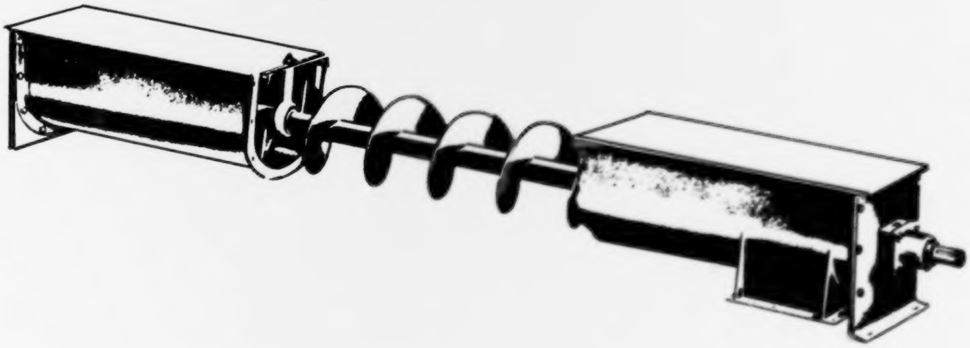


D. Wheel

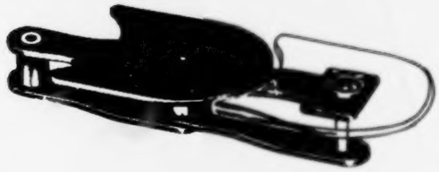


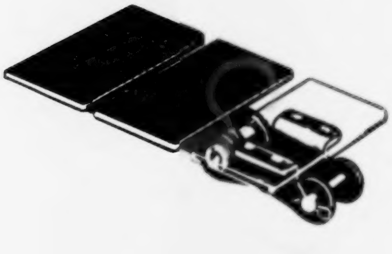
INFORMATION SHEET

E. Screw



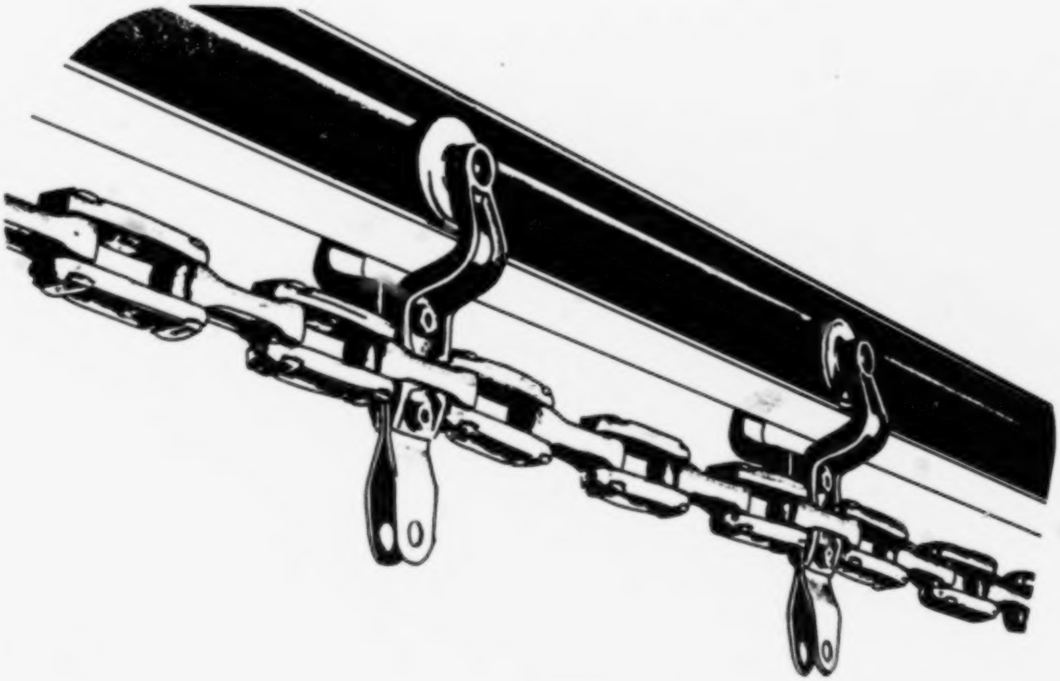
F. Flat top (table-top)





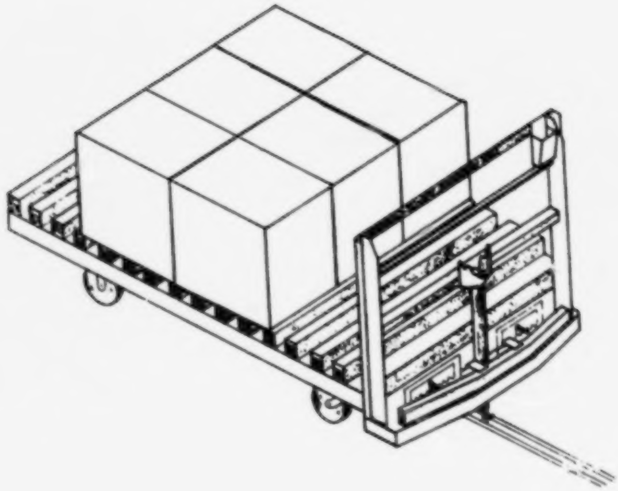
INFORMATION SHEET

G. Trolley

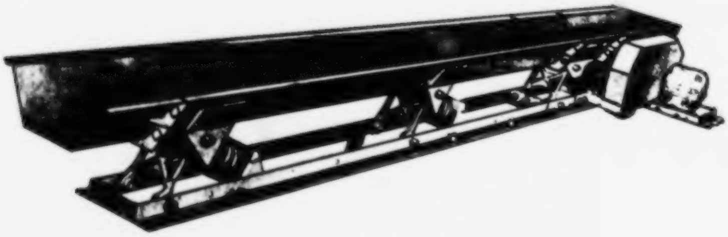


INFORMATION SHEET

H. In-floor

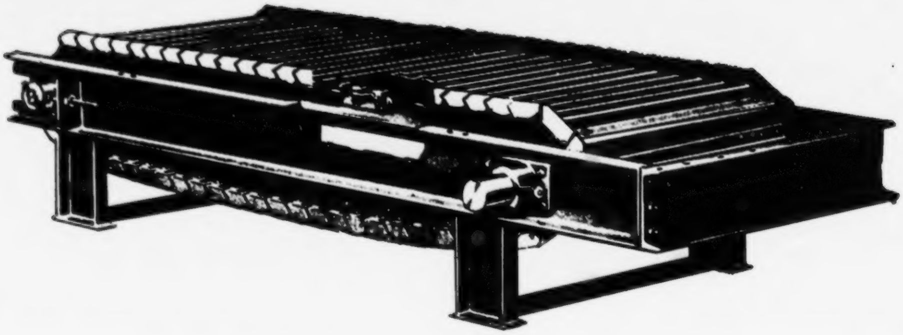


I. Oscillating

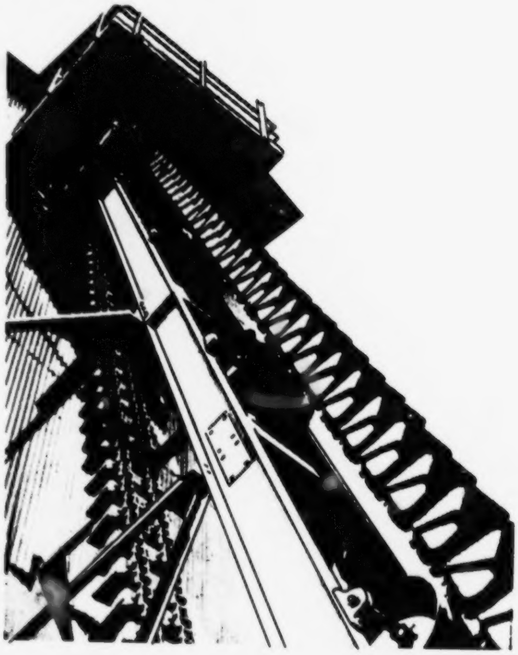


INFORMATION SHEET

J. Apron feeders



K. Bucket elevator



III. Specific types of conveyors

A. Bulk handling

B. Live roller

C. Hump back

INFORMATION SHEET

D. Compression

E. Table top

F. Screw

G. Trolley

H. Wheel type apron

I. In-floor

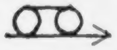
J. Roller bed belt

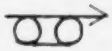
K. Gravity roller

L. Drag conveyor

M. Trough type belt (material handling)

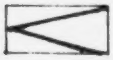
V. Symbols for plan view of a typical conveyor layout (Transparencies 1, 2, and 3)

A.  --Left hand drive

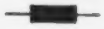
B.  --Right hand drive

C. 30 FPM --Speed

D. --Package flow

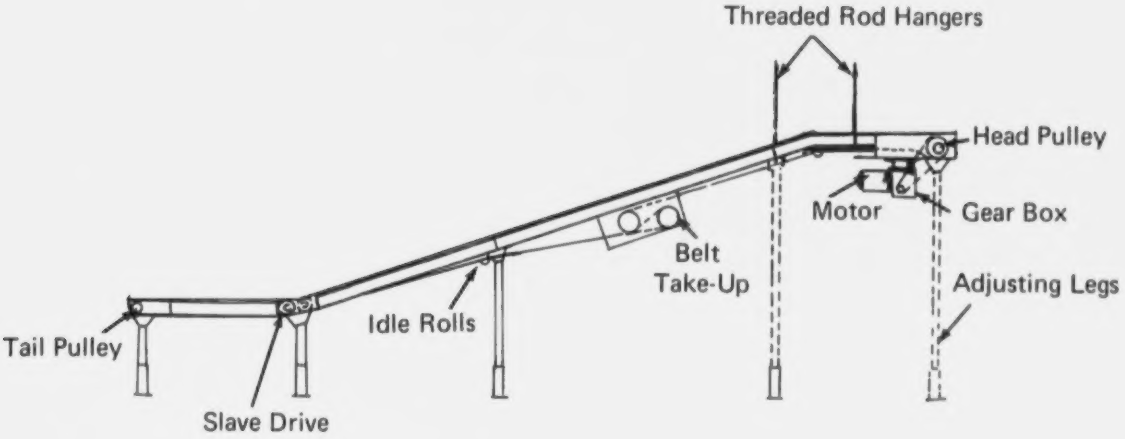
E.  --Gate

F. --Dimension line

G.  --Track inspection station

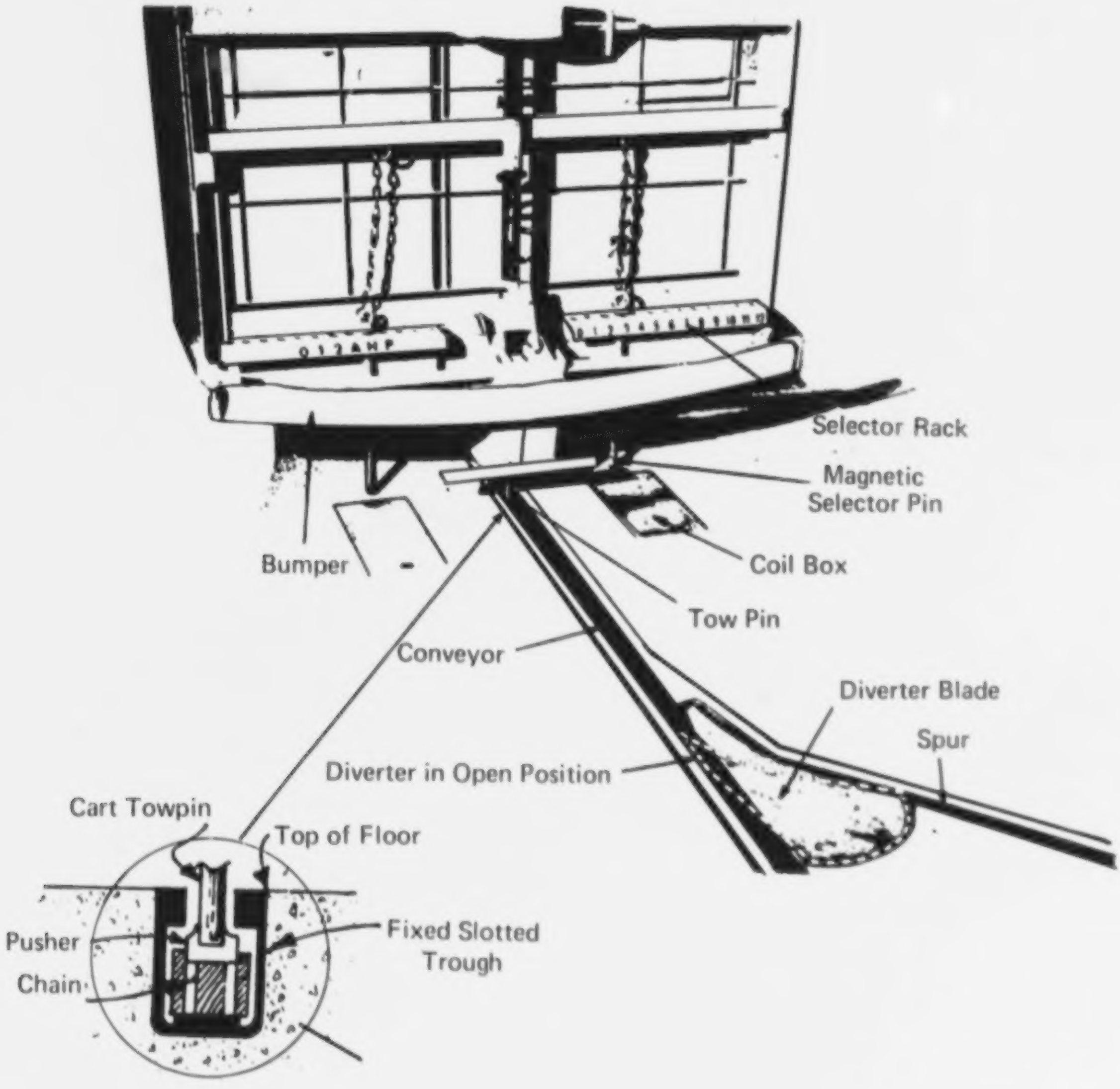
INFORMATION SHEET

V. Parts of a typical conveyor


Threaded Rod Hangers
Head Pulley
Motor
Gear Box
Belt Take-Up
Adjusting Legs
Idle Rolls
Tail Pulley
Slave Drive

INFORMATION SHEET

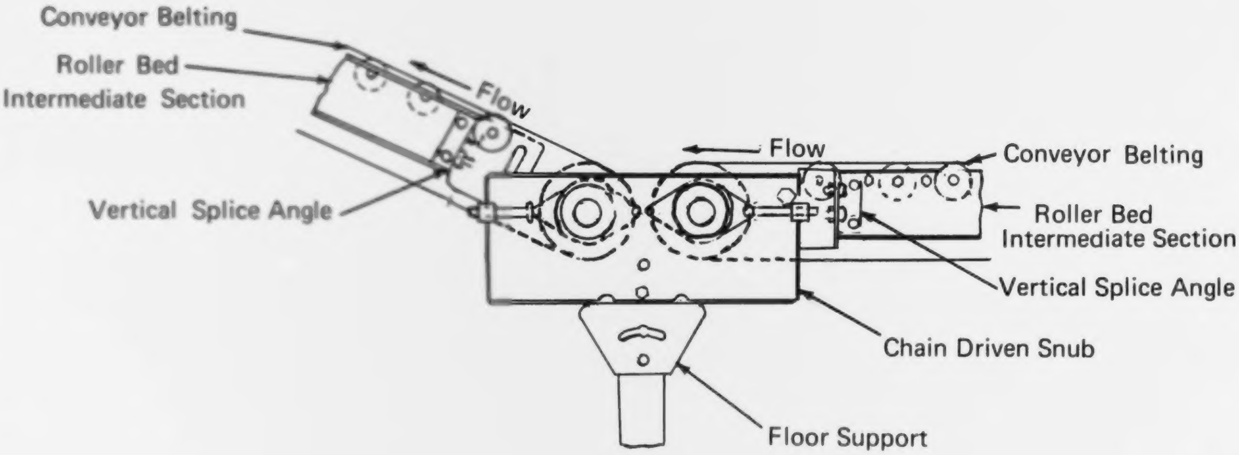
VI. Parts of an in-floor conveyor system


Selector Rack
Magnetic Selector Pin
Bumper
Coil Box
Tow Pin
Conveyor
Diverter Blade
Spur
Diverter in Open Position
Cart Towpin
Top of Floor
Pusher
Chain
Fixed Slotted Trough

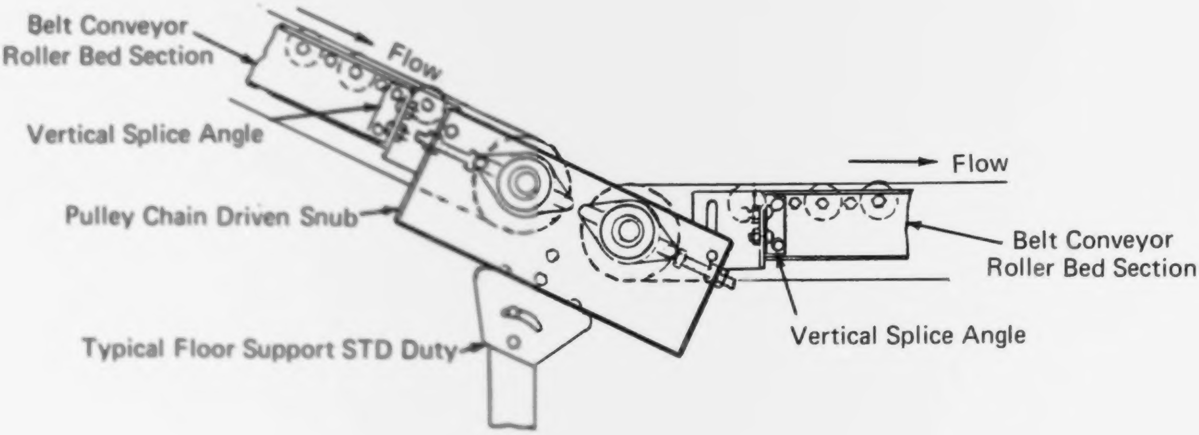
INFORMATION SHEET

VII. Typical flow detail for up or down service

A. Up service


Conveyor Belting
Roller Bed
Intermediate Section
Flow
Vertical Splice Angle
Flow
Conveyor Belting
Roller Bed
Intermediate Section
Vertical Splice Angle
Chain Driven Snub
Floor Support

B. Down service

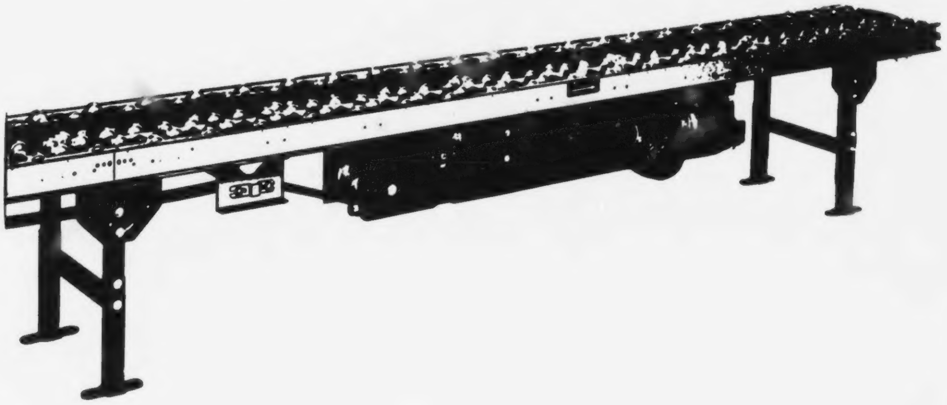

Belt Conveyor
Roller Bed Section
Flow
Vertical Splice Angle
Flow
Pulley Chain Driven Snub
Belt Conveyor
Roller Bed Section
Vertical Splice Angle
Typical Floor Support STD Duty

INFORMATION SHEET

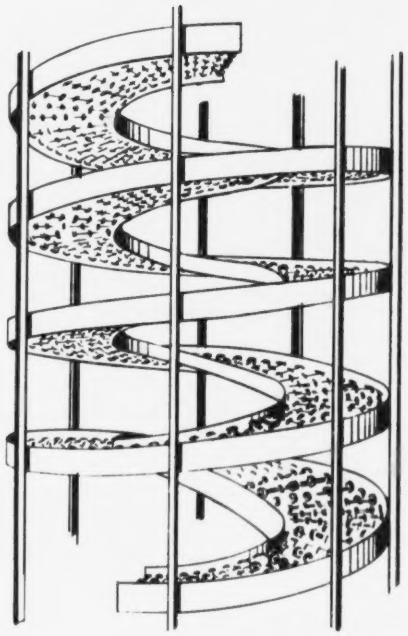
VIII. Components of a conveyor system

(NOTE: These are only a few of the many types of components.)

A. Accumulation control

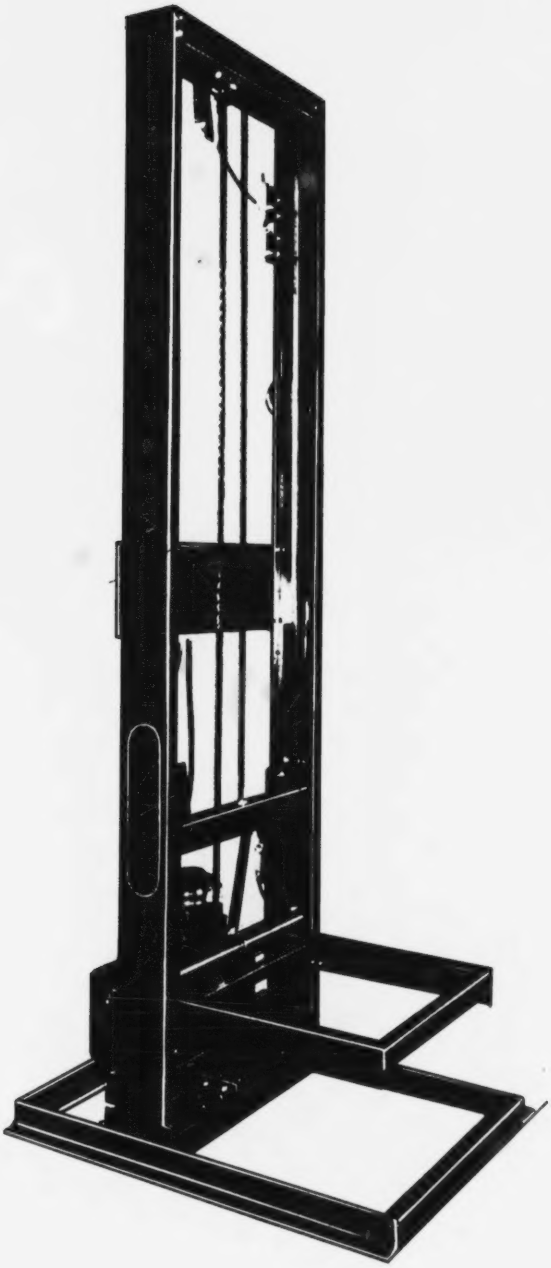


B. Gravity spiral



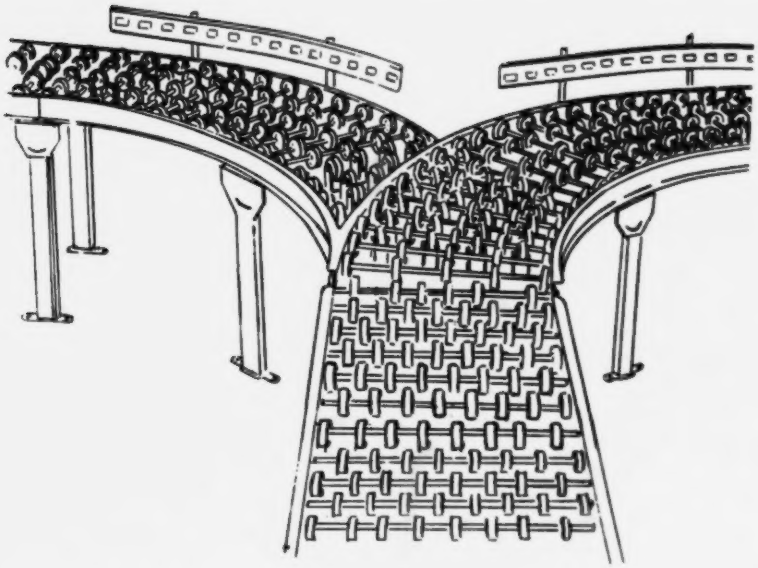
INFORMATION SHEET

C. Vertical

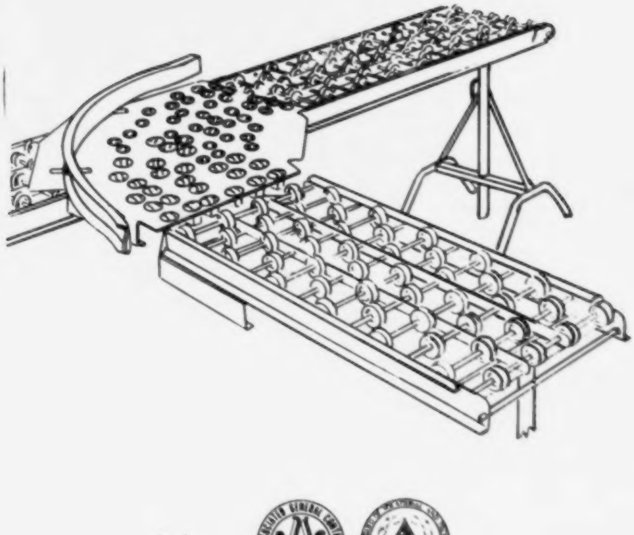


INFORMATION SHEET

D. "Y" switch

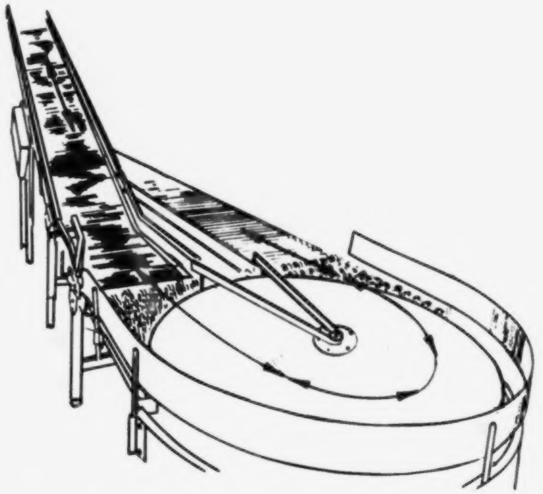


E. Flow diverter

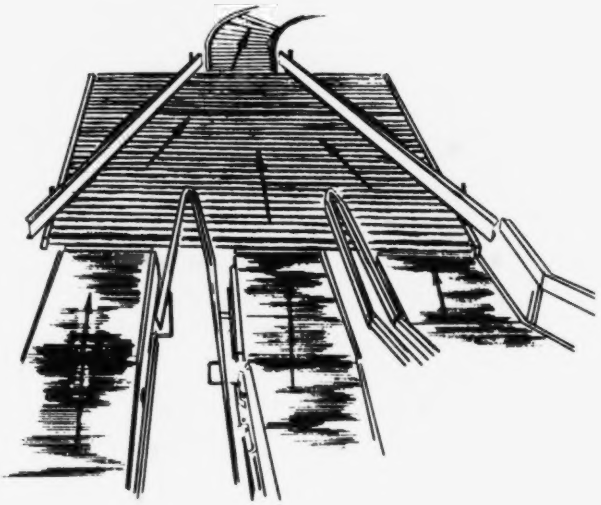


INFORMATION SHEET

F. Turntable

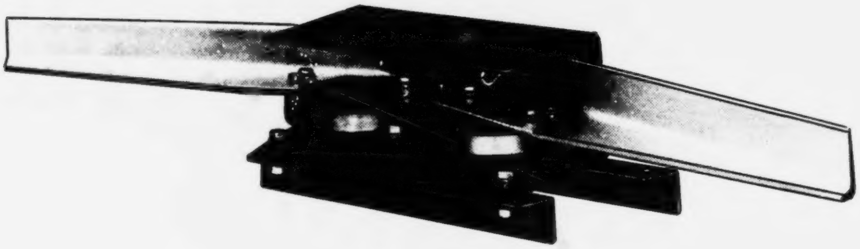


G. Converging section



INFORMATION SHEET

H. Traffic controller



IX. Items to check before start-up

A. Gear case or reducer is correctly filled with lubricant

(NOTE: All lubricants should be used according to manufacturer's specifications.)

B. Gear case vent plug has been installed in place of solid plug

C. Vent, drain, and oil level plugs are located according to diagram on manufacturer's tag

D. All persons are clear of conveyor

E. Conveyor bed is free from all tools and equipment

F. Proper safety devices such as pop-out rollers and chain guards are in place

G. Take-up is correct

H. Drive is in alignment

I. Set screws in all pulleys are tight

J. Belt has been tracked and is correct

INFORMATION SHEET

X. Types of support structures for conveyors (Transparencies 4-7)

  A. Overhead threaded rod hanger

  B. Overhead angle iron hanger

  C. Support legs with adjustable top bracket

  D. Support legs with adjustable threaded top

  E. Multiple deck support

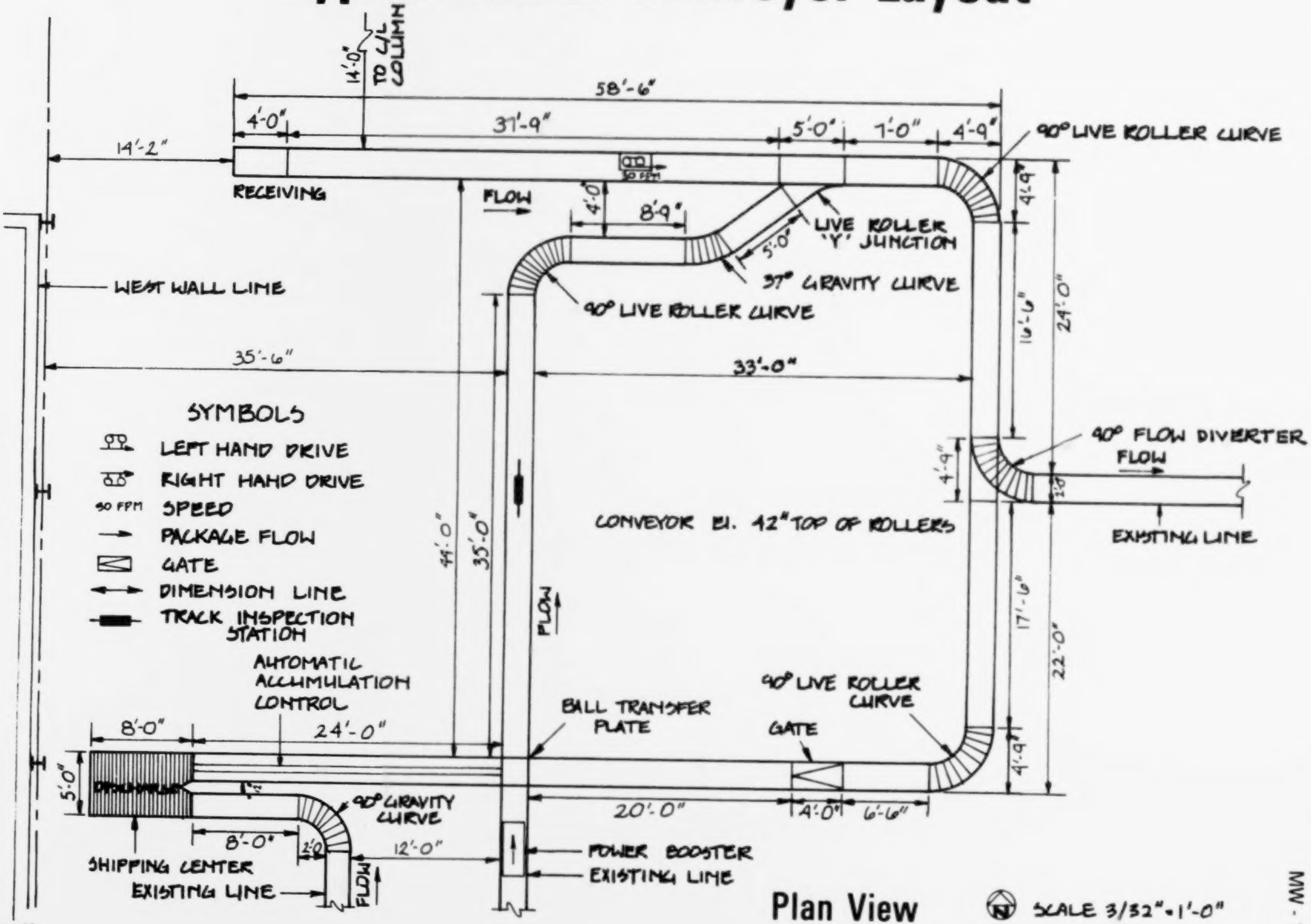
  F. Screw jack type

  G. Adjustable with diagonal brace

  H. Adjustable ceiling hanger

  I. Stands for temporary conveyors

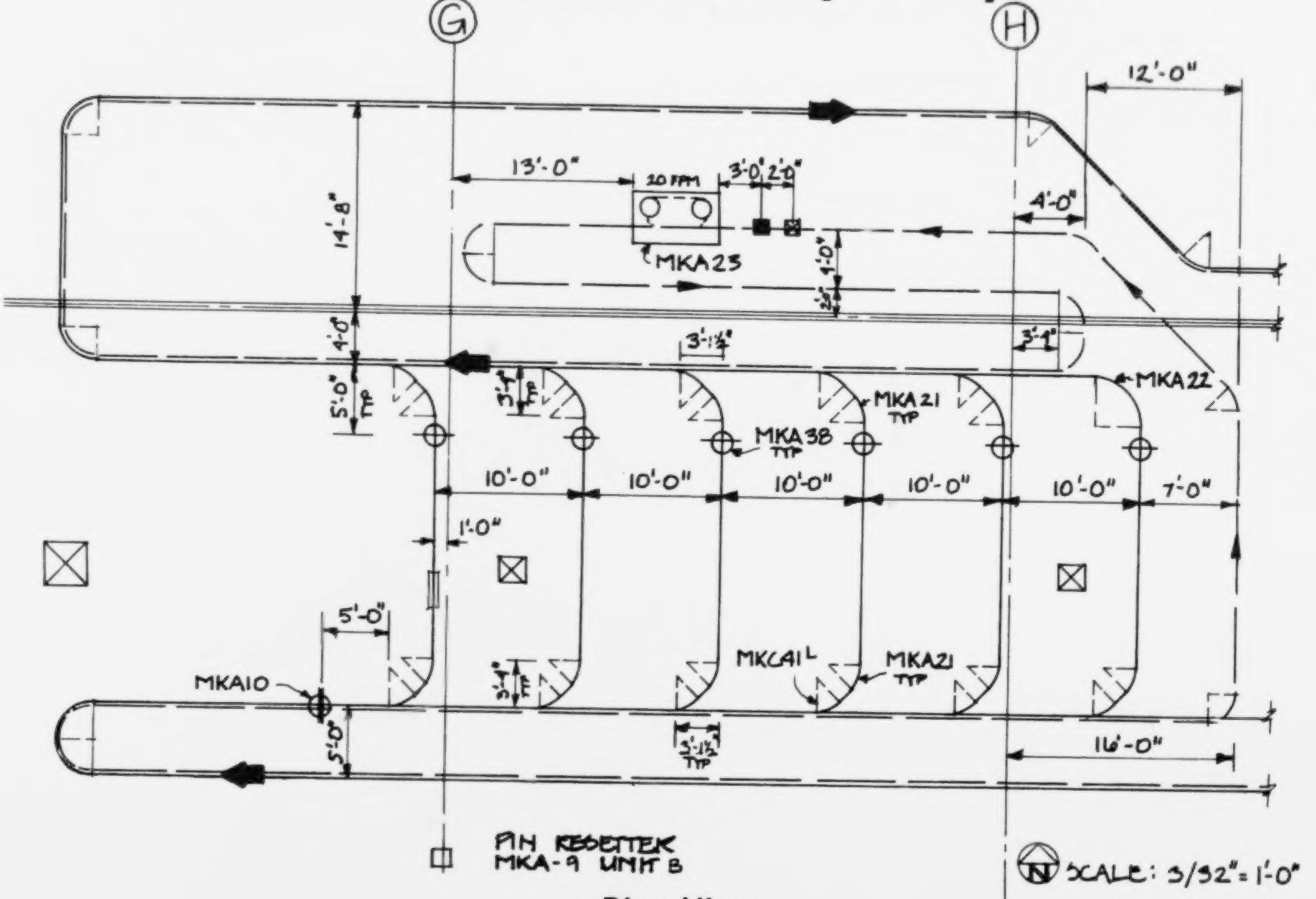
Typical Roller Conveyor Layout


14'-0" TO C/L COLUMN
58'-6"
4'-0"
37'-9"
5'-0"
7'-0"
4'-9"
90° LIVE ROLLER CURVE
14'-2"
RECEIVING
50 FPM
FLOW
4'-0"
8'-9"
LIVE ROLLER 'Y' JUNCTION
5'-0"
37° GRAVITY CURVE
90° LIVE ROLLER CURVE
4'-9"
16'-6"
24'-0"
WEST WALL LINE
35'-6"
33'-0"
SYMBOLS
LEFT HAND DRIVE
RIGHT HAND DRIVE
50 FPM SPEED
PACKAGE FLOW
GATE
DIMENSION LINE
TRACK INSPECTION STATION
90° FLOW DIVERTER
FLOW
4'-9"
2'0"
CONVEYOR EL. 42" TOP OF ROLLERS
EXISTING LINE
49'-0"
35'-0"
FLOW
17'-6"
22'-0"
AUTOMATIC ACCUMULATION CONTROL
BALL TRANSFER PLATE
90° LIVE ROLLER CURVE
GATE
4'-9"
8'-0"
24'-0"
5'-0"
20'-0"
4'-0"
6'-6"
90° GRAVITY CURVE
8'-0"
2'0
12'-0"
POWER BOOSTER
EXISTING LINE
SHIPPING CENTER
EXISTING LINE
FLOW

Plan View

SCALE 3/32" = 1'-0"

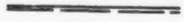
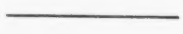
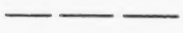
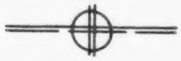
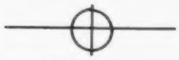
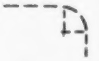
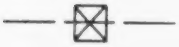
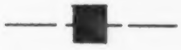
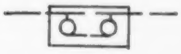
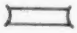
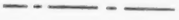
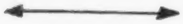
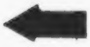
Typical Overhead Conveyor Layout


G
H
12'-0"
13'-0"
20 FPM
3'-0"
2'-0"
4'-0"
14'-8"
MKA23
4'-0"
2'-6"
3'-1½"
3'-1"
MKA22
5'-0" TYP
3'-4" TYP
MKA21 TYP
MKA38 TYP
10'-0"
10'-0"
10'-0"
10'-0"
10'-0"
7'-0"
1'-0"
5'-0"
MKA10
MKC41L
MKA21 TYP
3'-4" TYP
3'-1½" TYP
5'-0"
16'-0"
PIN RESETTER
MKA-9 UNIT B
N
SCALE: 3/32" = 1'-0"

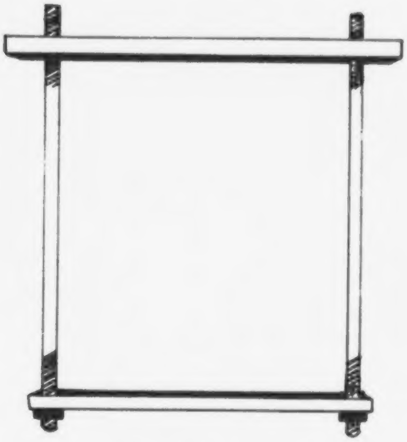
Plan View

Symbols for a Typical Overhead Conveyor Layout

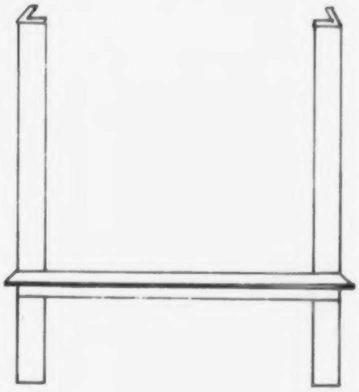
All elevations are given from finished first floor to top of 4" power rail unless noted
All power and power only vertical bends are 10'-0" rad. 30° maximum (unless noted)
All switches are 24" rad.
All power only horizontal turns are 24" rad. (unless noted)
All power and free horizontal turns are 2'-6" rad. (90° MKA3 45° MKA4)
All free horizontal turns are 2'-6" rad. (90° MKA22 45° MKA21)

	Power and free-track (elevation to top I-beam) MKA-1
	Free-track (P&F) (Elevation bottom ES3)
	Power only track (Elevation to top I-beam)
	Air-operated P&F stop MKA10
	Manually operated free line stop MKA38
	Roller turn 2'-0" rad. unless noted
	Opco chain pin oiler
	Opco power trolley oiler
	Rotary cat drive
	Inspection gate
	Tool rail (T.R.)
	Dimension line
20 FPM	Speed
	Flow

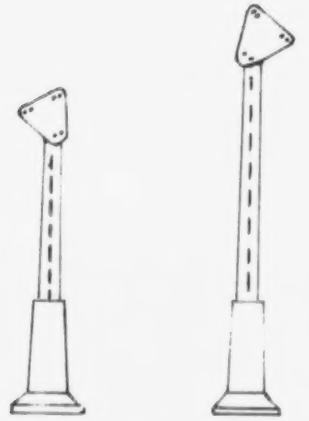
Types of Support Structures



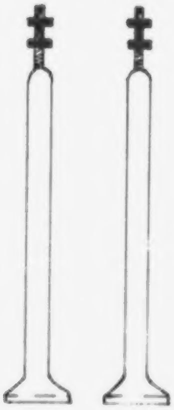
Overhead Threaded
Rod Hanger



Overhead Angle
Iron Hanger



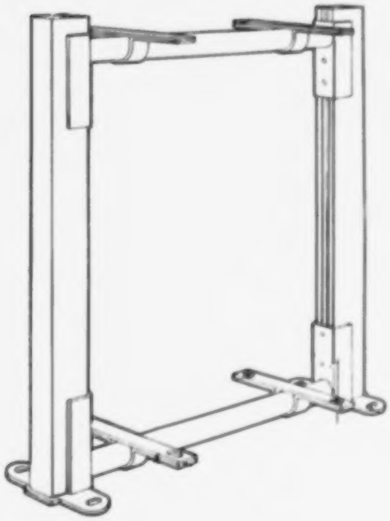
Support Legs with
Adjustable Top Bracket



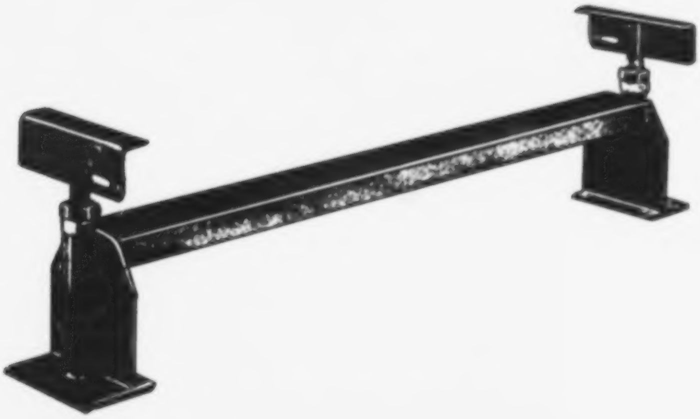
Support Legs with
Adjustable Threaded Top

Types of Support Structures

(Continued)



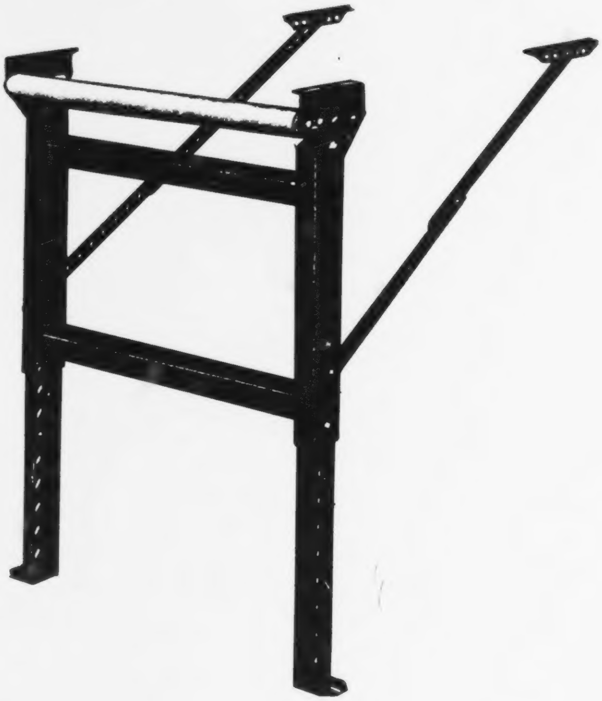
Multiple Deck Support



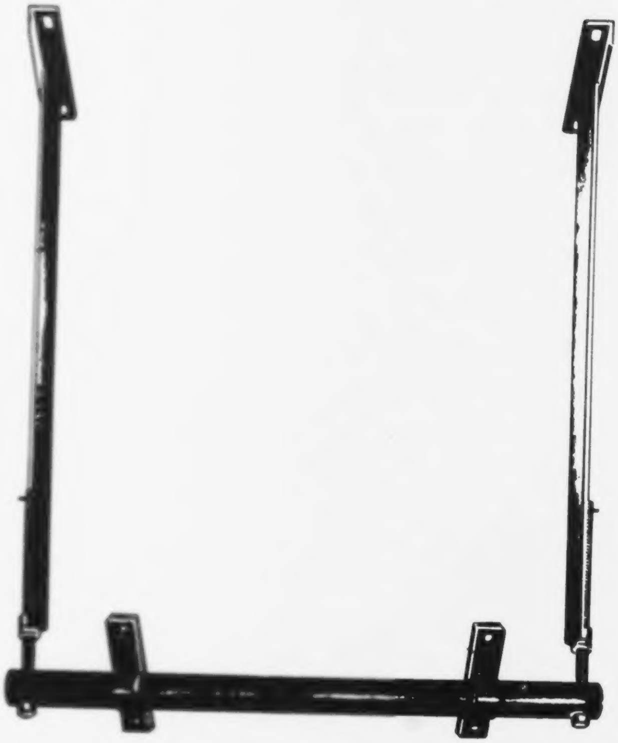
Screw Jack Type

Types of Support Structures

(Continued)

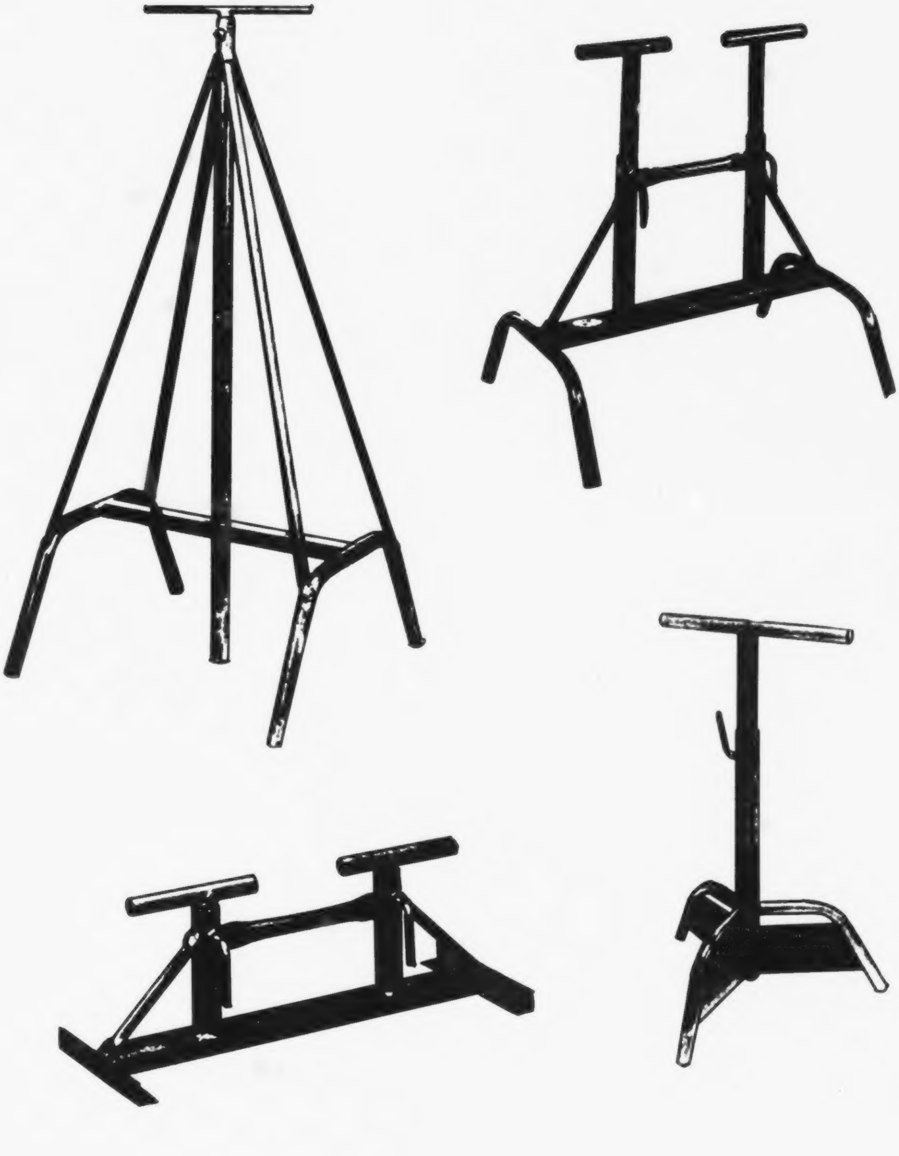


Adjustable with
Diagonal Brace



Adjustable Ceiling
Hanger

Types of Support Structures
(Continued)



Stands for Temporary Conveyors

CONVEYORS AND SUPPORT STRUCTURES
UNIT IV

JOB SHEET #1--INSTALL CONVEYOR AND COMPONENTS USING BASIC STEPS

I. Tools and equipment

A. Blueprints

B. Tapes, 100' and 8'

C. Assorted wrenches

D. Lifting device

E. Chalk box and line

F. Mechanic's level

G. Straight edge

II. Procedure

A. Lay out all components in proper sequence in area where conveyor will be erected

B. Check area for obstructions

C. Confirm building dimensions, wall and floor openings, column lines, and any other equipment within specification dimensions

D. Establish center line points on floor

E. Chalk lines between these center line points

(NOTE: If conveyor unit is exceedingly long it may be necessary to establish intermediate base points with a transit.)

F. Erect support legs and/or hangers

G. Install conveyor

H. Level across conveyor while erecting

(NOTE: It is absolutely necessary that all pulleys, bed rolls, and return rolls are level across the width of conveyors and at right angles to center line of conveyor.)

I. Check to see that rollers are set square or at right angles to side frames and/or center lines

J. Maintain a constant pitch on pitched gravity lines to prevent dips, dead spots, or uneven rate of travel

(NOTE: In most cases maximum angle of incline is 21°.)

JOB SHEET #1

K. Use a straight edge over at least three rollers at ends of adjoining sections when connecting sections together

(NOTE: This assures perfect elevation alignment.)

L. Align roller section guardrails to prevent interference of package travel

(NOTE: Use manufacturer's connectors at all belt conveyor to belt driven live roll conveyor joints or differences in elevation from one conveyor to another.)

CONVEYORS AND SUPPORT STRUCTURES
UNIT IV

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with conveyors and support structures to the correct definitions. Place the correct numbers in the blanks provided.

   ______a. Equipment designed to move materials vertically and horizontally from one point to another

   ______b. System with power transmitted by a fixed-speed endless chain moving through a steel trough which, at intervals, has connectors that connect to the carts

   ______c. Type of conveyor in which power is transmitted to only these rollers

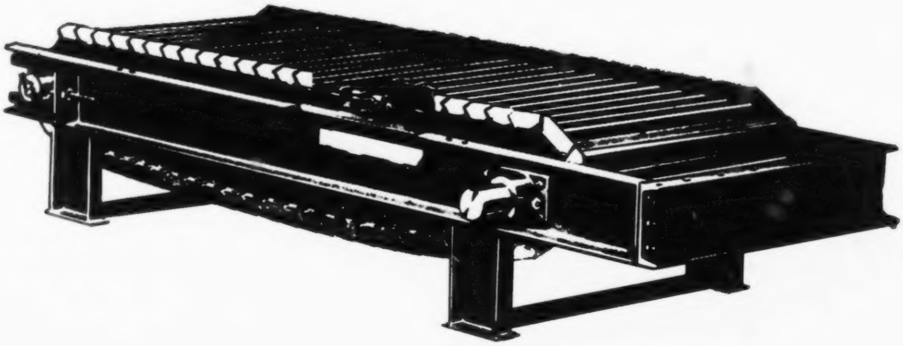
   ______d. Roller without power transmitted to it

   ______e. Type of overhead conveyor

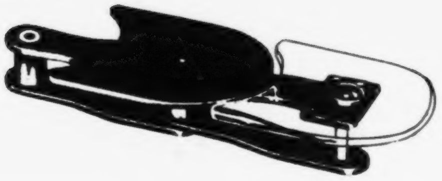
   ______f. Legs and/or hangers that support conveyors

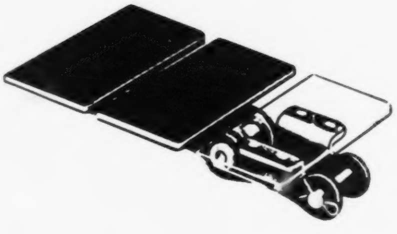
   1. Trolley
   2. In-floor (tow-line) conveyor
   3. Dead roller (gravity-type)
   4. Support structures
   5. Conveyors
   6. Live rollers

2. Identify the following basic types of conveyors. Place the correct names in the blanks provided.



a. ______________________________





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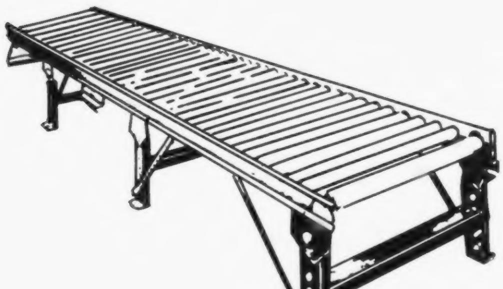
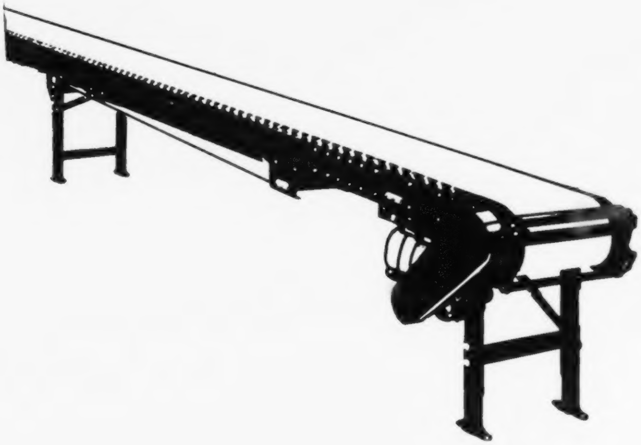
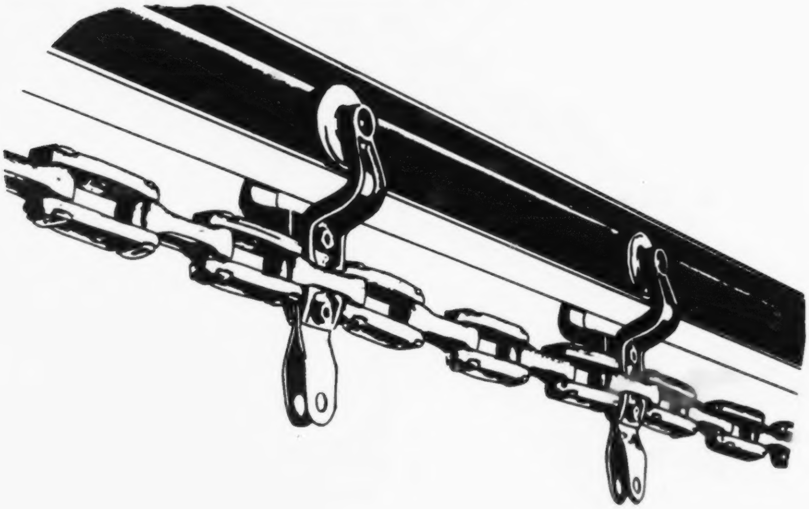


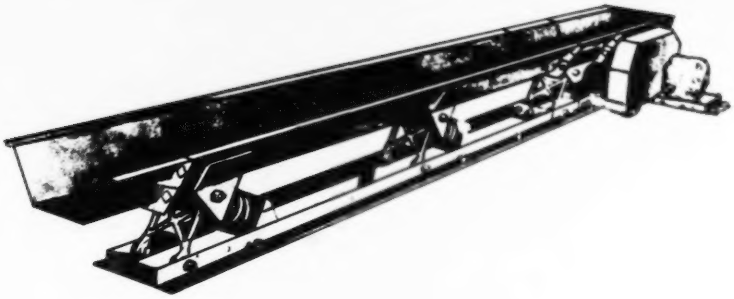
c. ____________________



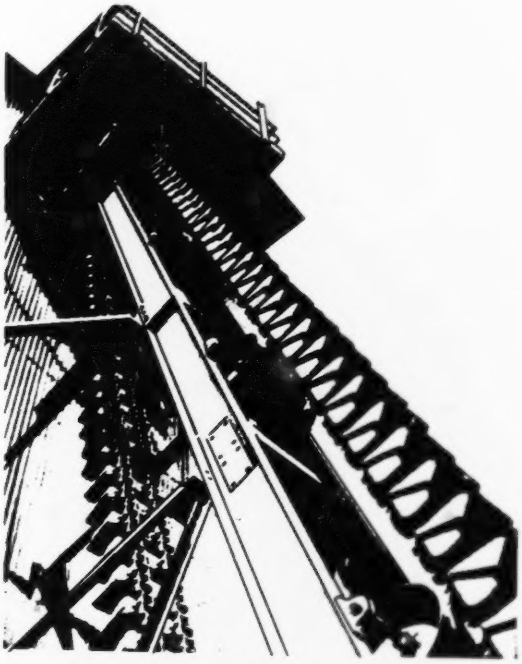
d. ______________________________



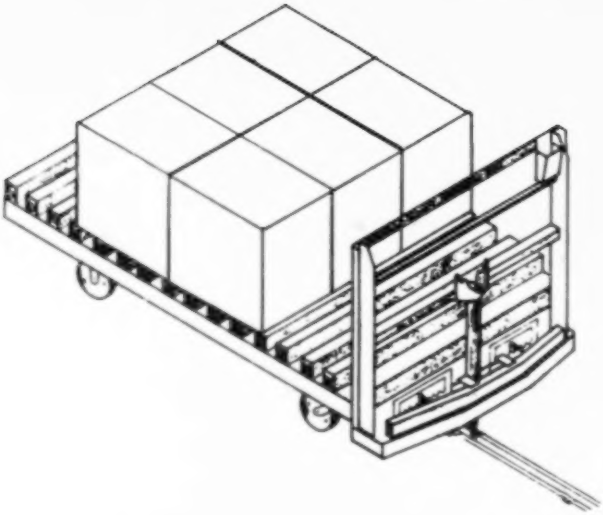
e. ______________________________



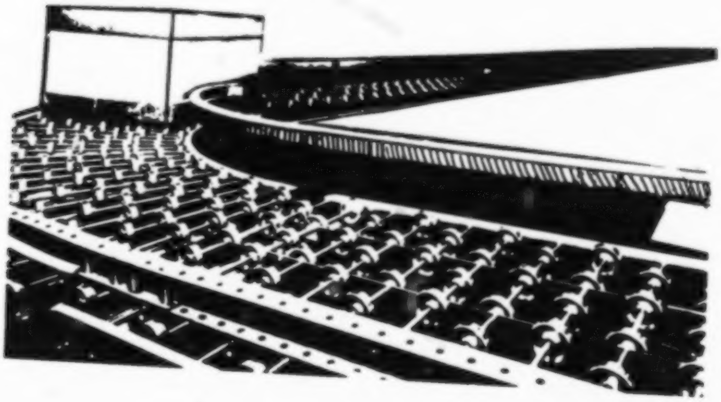
f. ______________________________



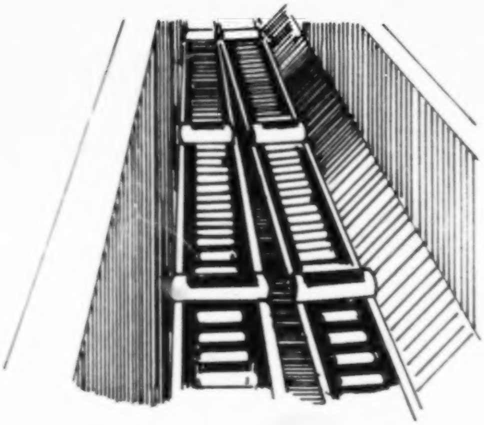
g. ______________________________



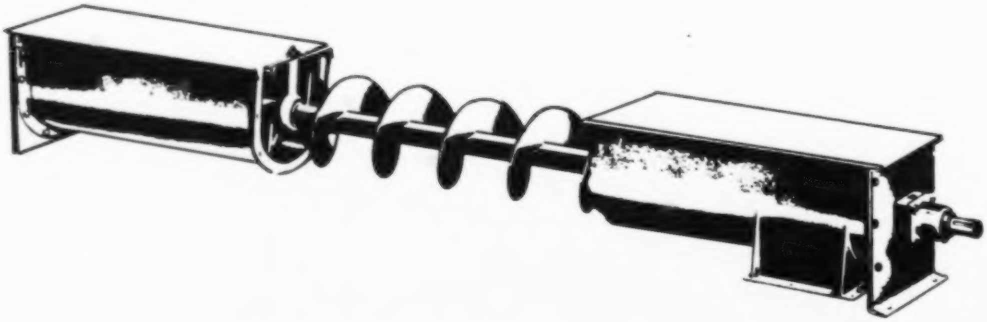
h. ______________________________



i. ______________________________



j. ______________________________



k. ______________________________

3. Select from following list specific types of conveyors. Place an "X" in the correct blanks.

______a. Bulk handling

______b. Hydraulic

______c. Live roller

______d. Camel back

______e. Chair top

______f. Compression

______g. Spring

______h. Trolley

______i. Wheel type apron

______j. Tow chain

______k. Roller bed belt

______l. Electric roller

______m. Drag

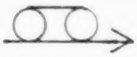
______n. V-belt

______o. Vertical

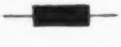
______p. Spiral

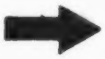
4. Identify symbols for a typical conveyor layout.

30 FPM

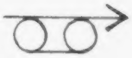


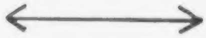
a. ______________________________ b. ______________________________



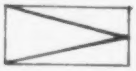


c. ______________________________ d. ______________________________



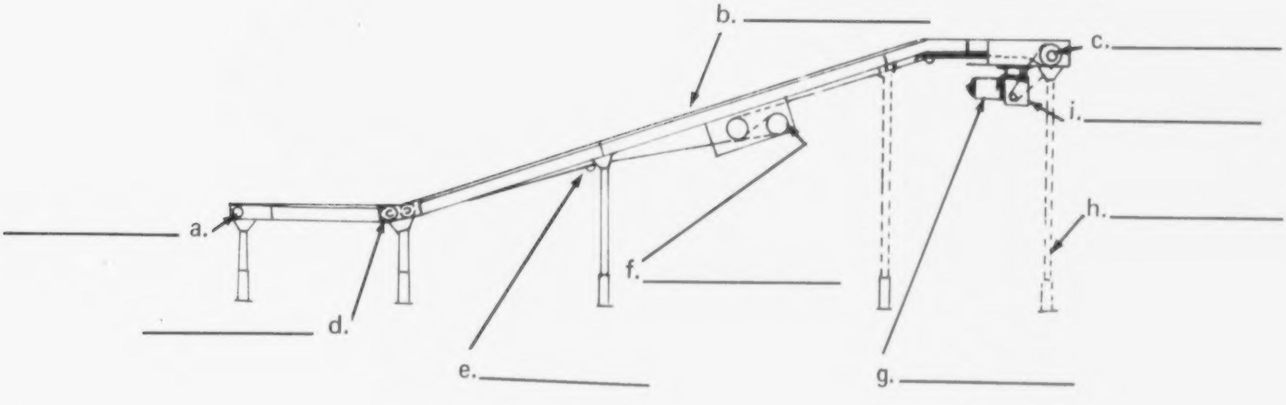


e. ______________________ f. ______________________

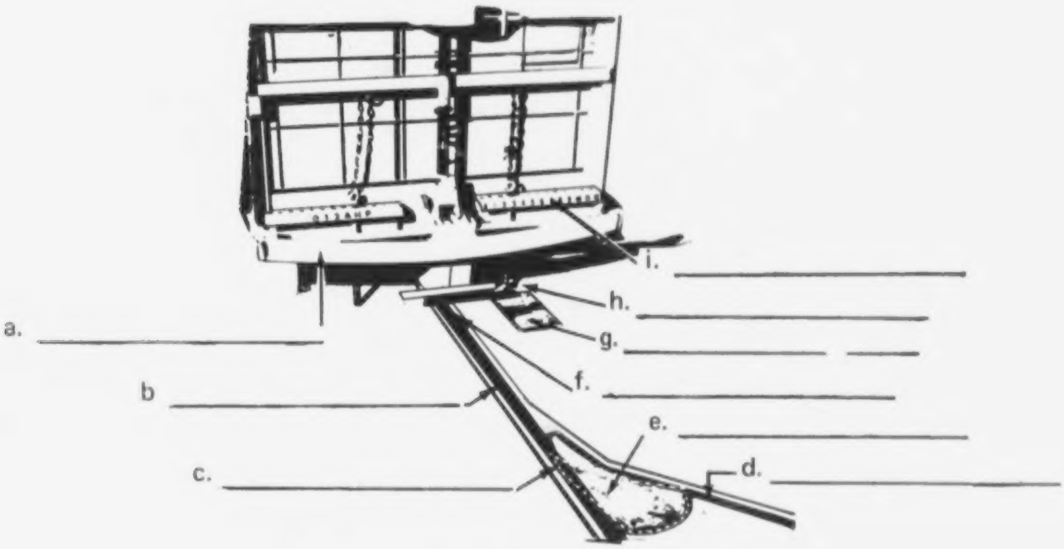


g. ______________________

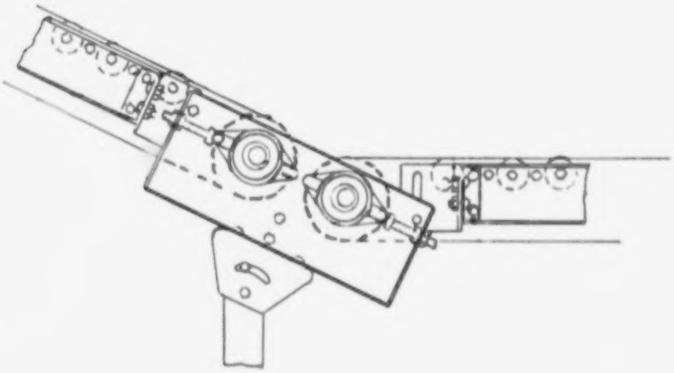
5. Identify parts of a typical conveyor. Place the correct names in the blanks provided.



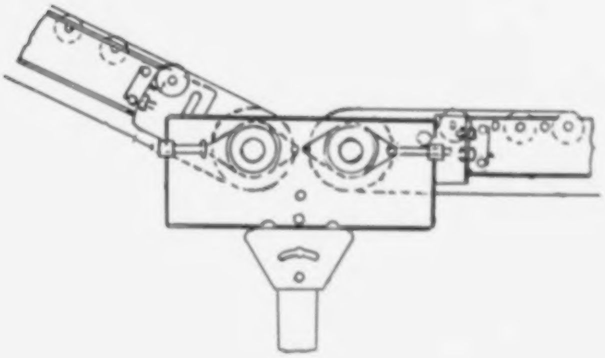
6. Identify parts of an in-floor conveyor system. Write the correct names in the blanks provided.



7. Distinguish between the typical flow detail for up or down service. Place a "D" in the blank that represents down service and a "U" in the blank representing up service.

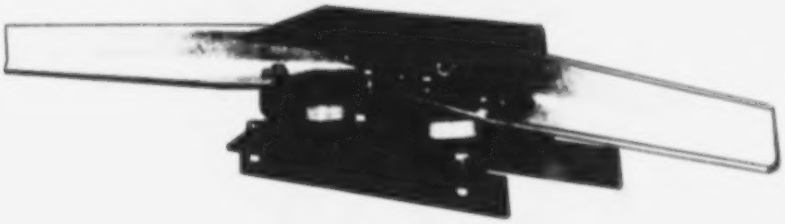


a. ________________________

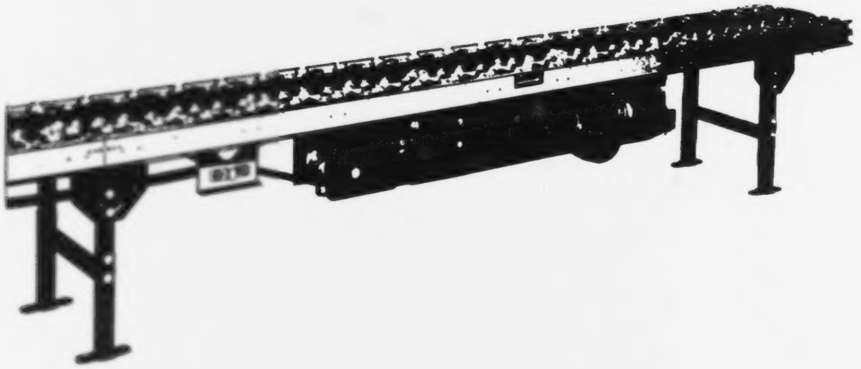


b. ________________________________

8. Identify components of a conveyor system. Write the correct names in the blanks provided.



a. ________________________________



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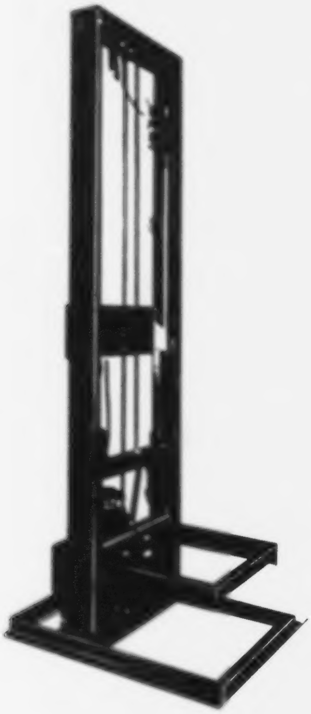
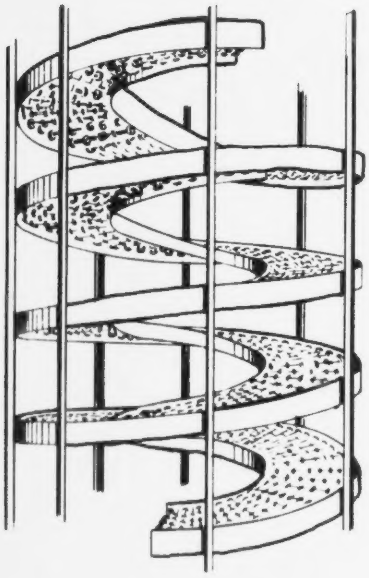
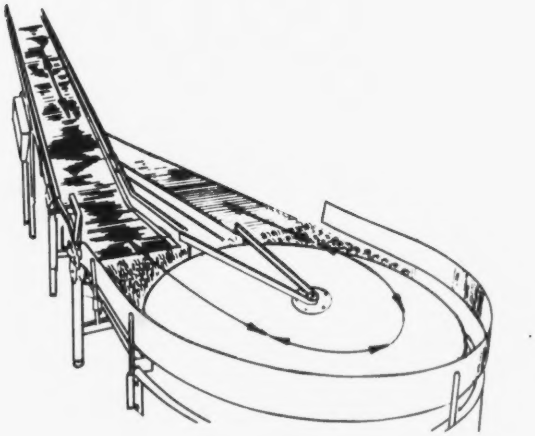
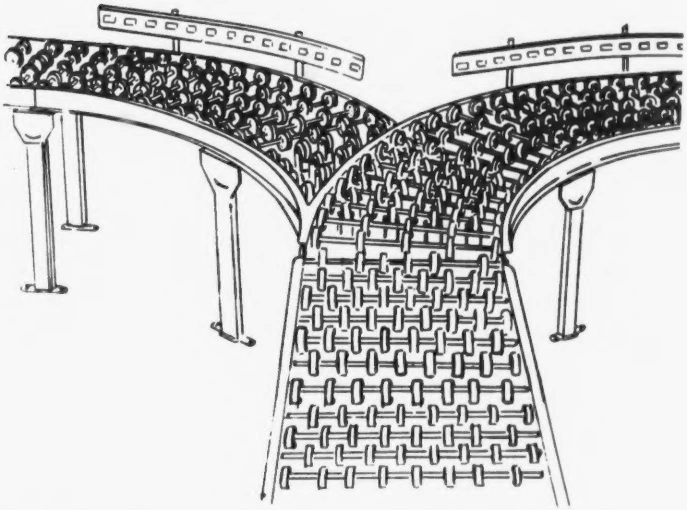




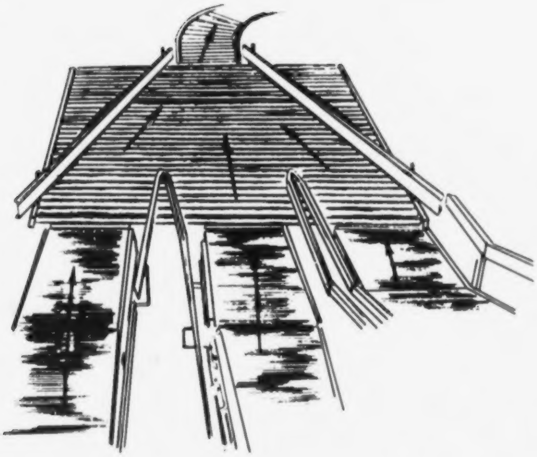
c. ____________________ d. ____________________

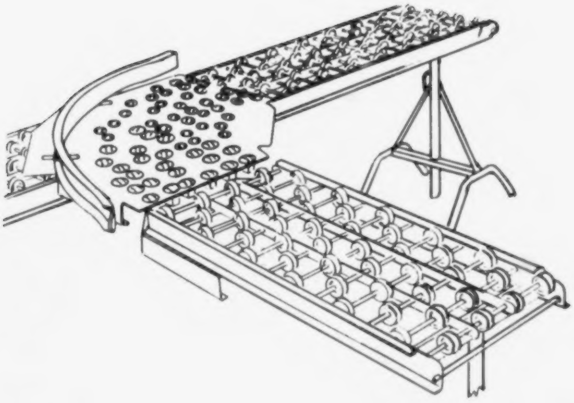


e. ______________________________



f. ______________________________





g. ____________________ h. ____________________

9. List items to check before start-up.

a. ____________________

b. ____________________

c. ____________________

d. ____________________

e. ____________________

f. ____________________

g. ____________________

h. ____________________

i. ____________________

j. ____________________

10. List types of support structures for conveyors.

a. ____________________

b. ____________________

c. ____________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

11. Demonstrate the ability to install conveyor and components using basic steps.

(NOTE: If the above activity has not been accomplished prior to the test, ask the instructor when it should be completed.)

CONVEYORS AND SUPPORT STRUCTURES
UNIT IV

ANSWERS TO TEST

1. a. 5
    b. 2
    c. 6
    d. 3
    e. 1
    f. 4
2. a. Apron feeders
    b. Flat top (table-top)
    c. Roller
    d. Belt
    e. Trolley
    f. Oscillating
    g. Bucket elevator
    h. In-floor
    i. Wheel
    j. Chain
    k. Screw
3. a, c, f, h, i, k, m, o, p
4. a. Speed
    b. Left hand drive
    c. Track inspection station
    d. Package flow
    e. Right hand drive
    f. Dimension line
    g. Gate

5. a. Tail pulley
  b. Belt
  c. Head pulley
  d. Slave drive
  e. Idle rolls
  f. Belt take-up
  g. Motor
  h. Adjusting legs
  i. Gear box

6. a. Bumper
  b. Conveyor
  c. Diverter in open position
  d. Spur
  e. Diverter blade
  f. Tow pin
  g. Coil box
  h. Magnetic selector pin
  i. Selector rack

7. a. U
  b. D

8. a. Traffic controller
  b. Accumulation control
  c. Vertical
  d. Gravity spiral
  e. Turntable
  f. "Y" switch
  g. Converging section
  h. Flow diverter

9. a. Gear case or reducer is correctly filled with lubricant
   - b. Gear case vent plug has been installed in place of vent plug
   - c. Vent, drain, and oil level plugs are located according to diagram on manufacturer's tag
   - d. All persons are clear of conveyor
   - e. Conveyor bed is free from all tools and equipment
   - f. Proper safety devices such as pop-out rollers and chain guards are in place
   - g. Take-up is correct
   - h. Drive is in alignment
   - i. Set screws in all pulleys are tight
   - j. Belt has been tracked and is correct

10. a. Overhead threaded rod hanger
    - b. Overhead angle iron hanger
    - c. Support legs with adjustable top bracket
    - d. Support legs with adjustable threaded top
    - e. Multiple deck support
    - f. Screw jack
    - g. Adjustable with diagonal brace
    - h. Adjustable ceiling hanger
    - i. Stands for temporary conveyors

11. Performance skills evaluated to the satisfaction of the instructor

GEAR BOXES AND SPEED REDUCERS
UNIT V

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify different types of gear boxes, speed reducers and lubricators. The student should also be able to describe the advantage of variable speed drives. This knowledge will be evidenced by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with gear boxes and speed reducers to the correct definitions.
2. Identify basic types of gear boxes and speed reducers.
3. List specific uses of variable speed drives.
4. Describe the advantage of variable speed drives.
5. Select from illustrations speed settings for maximum speeds.
6. Identify types of lubricators.

GEAR BOXES AND SPEED REDUCERS
UNIT V

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide students with objective sheet.

  B. Make transparencies.

  C. Provide students with information sheet.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Give test.

II. Instructional materials:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Types of Lubricators

    2. TM 2--Types of Lubricators (Continued)

    3. TM 3--Types of Lubricators (Continued)

    4. TM 4--Types of Lubricators (Continued)

  D. Test

  E. Answers to test

III. Unit references:

  A. *Maintenance Millwright I: Training Module.* Houston, Texas: Brown and Root, Inc., n.d.

  B. *Link-Belt Products and Components for Materials Handling and Power Transmission.* Catalog 1050. 4th ed. Indianapolis, Indiana: Link-Belt Company, 1965.

GEAR BOXES AND SPEED REDUCERS
UNIT V

INFORMATION SHEET

I. Terms and definitions

A. Variable speed drive--Device which provides simple, quick, and precise speed control to meet varying requirements

B. Helical--Related to or having the form of a helix

C. Helix--Object having spiral form

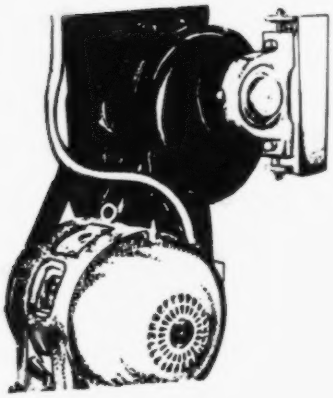
Example: Coil

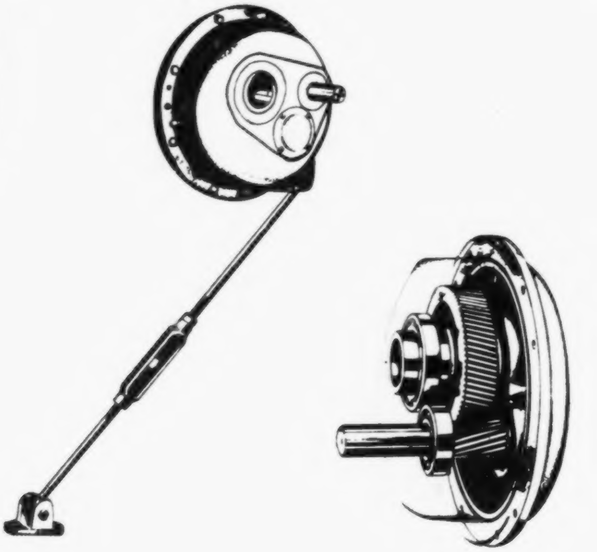
D. Fluid drive--Power coupling which operates on a hydraulic turbine principle

E. Conical--Resembling a cone in shape

II. Basic types of gear boxes and speed reducers

A. Shaft-mounted speed reducer





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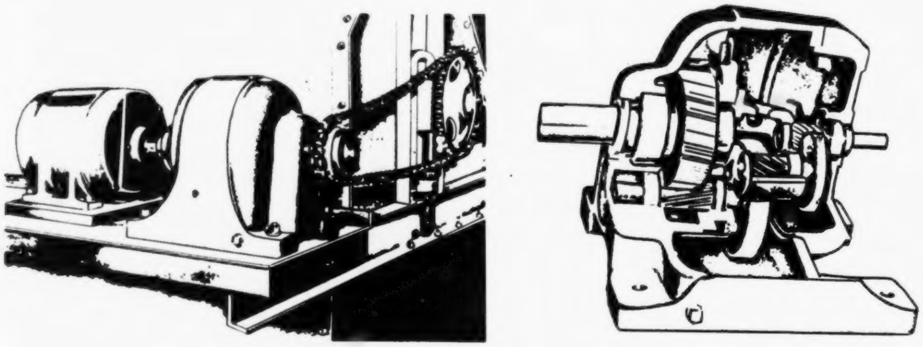
INFORMATION SHEET

B. In-line helical gear speed reducer



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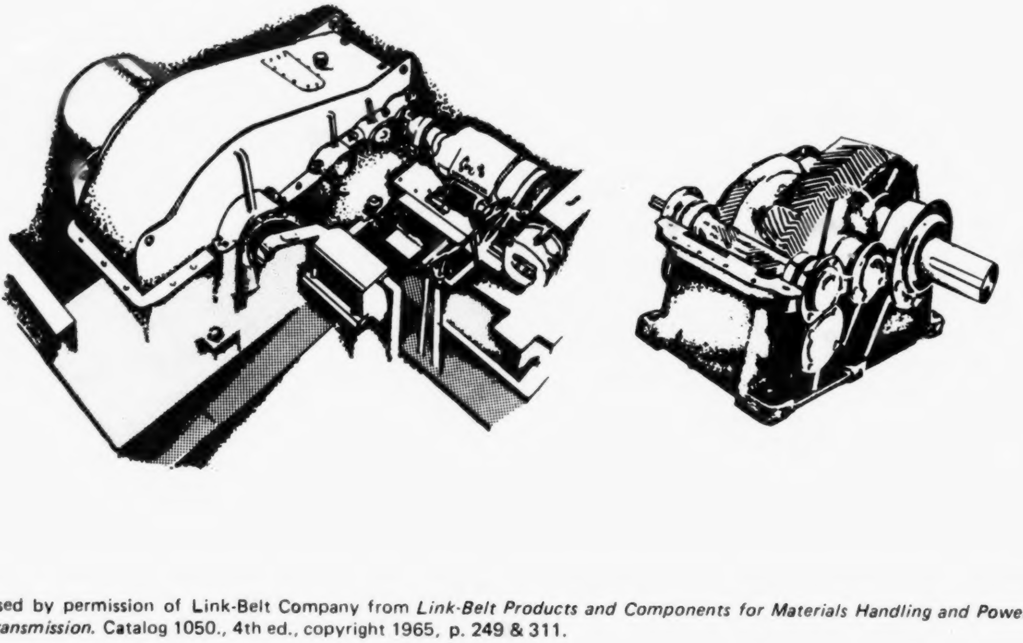
C. Parallel shaft speed reducer



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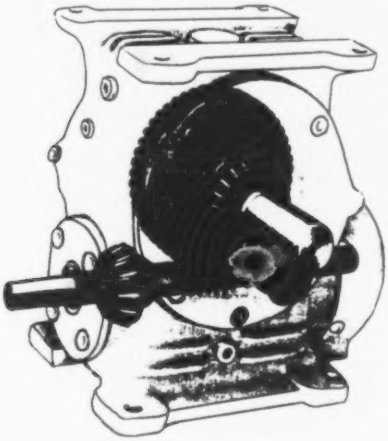
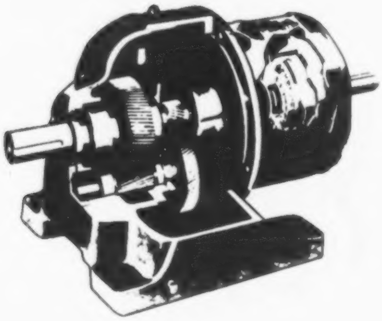
INFORMATION SHEET

D. Worm gear speed reducer



Used by permission of Link-Belt Company from *Link-Belt Products and Components for Materials Handling and Power Transmission.* Catalog 1050., 4th ed., copyright 1965, p. 326.

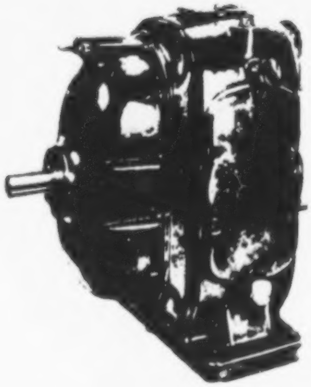
E. Fluid gear drive



Used by permission of Link-Belt Company from *Link-Belt Products and Components for Materials Handling and Power Transmission.* Catalog 1050., 4th ed., copyright 1965, p. 291.

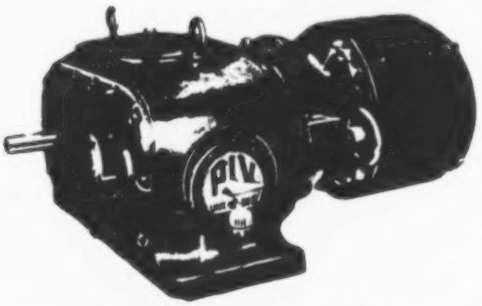
INFORMATION SHEET

F. Variable speed drive



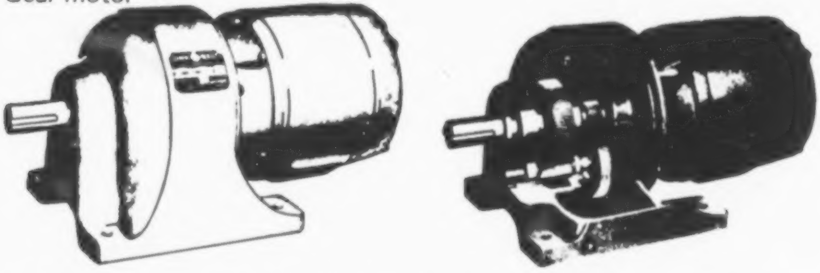
Used by permission of Link-Belt Company from *Link-Belt Products and Components for Materials Handling and Power Transmission.* Catalog 1050., 4th ed., copyright 1965, p. 252.

G. Variable speed drive with integrally mounted motor



Used by permission of Link-Belt Company from *Link-Belt Products and Components for Materials Handling and Power Transmission.* Catalog 1050., 4th ed., copyright 1965, p. 253.

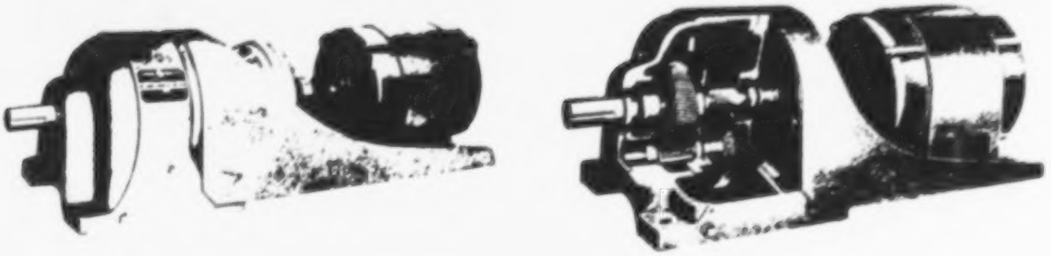
H. Gear motor



Used by permission of Link-Belt Company from *Link-Belt Products and Components for Materials Handling and Power Transmission.* Catalog 1050., 4th ed., copyright 1965, p. 289-290.

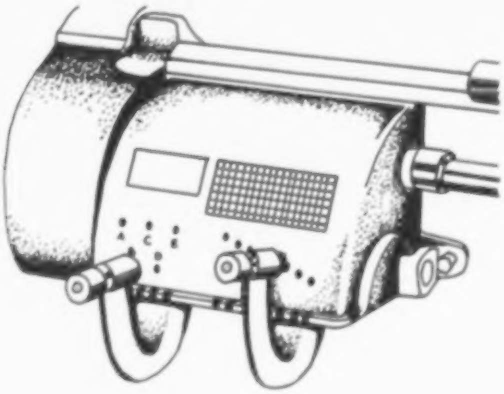
INFORMATION SHEET

I. Motogear



Used by permission of Link-Belt Company from *Link-Belt Products and Components for Materials Handling and Power Transmission.* Catalog 1050., 4th ed., copyright 1965, p.

J. Quick change gear box



III. Specific uses of variable speed drives

A. Timing of processes

Examples: Baking and heat treating equipment

B. Controlling length on all types of shears and cutters

C. Output on various types of handling systems

Examples: Conveyors and assembly lines

D. Production of various sizes, shapes, grades, and quantities of products on a single machine

E. Winding material on rolls at constant linear speed

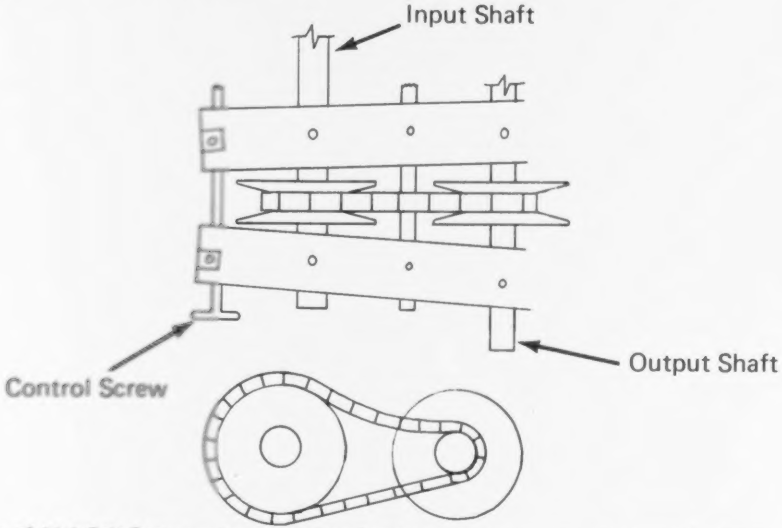
F. Synchronizing related machine components

INFORMATION SHEET

IV. Advantage of variable speed drives--Infinite speed variation

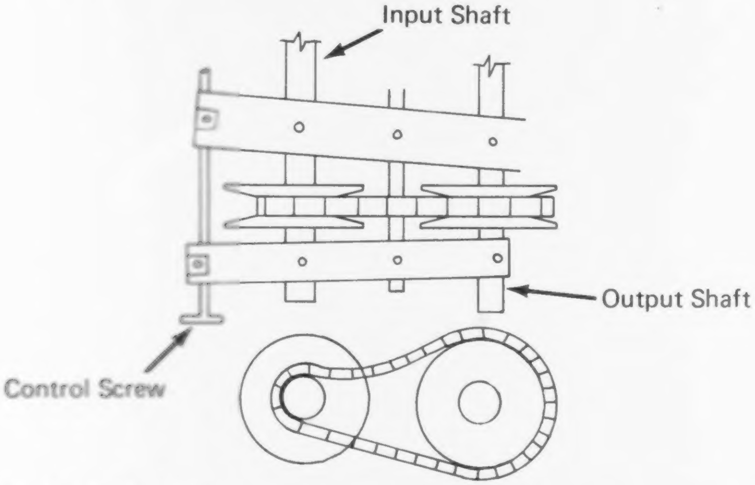
V. Speed settings for maximum speeds

A. Maximum--Conical wheels on input shaft are close together, forming a large diameter driving surface; those on output shaft are separated to form small diameter drive surface



Used by permission of Link-Belt Company from *Link-Belt Products and Components for Materials Handling and Power Transmission.* Catalog 1050., 4th ed., copyright 1965, p. 251.

B. Minimum--Conical wheels on input shaft are separated, forming a small diameter driving surface; those on output shaft are close together to form large diameter drive surface



Used by permission of Link-Belt Company from *Link-Belt Products and Components for Materials Handling and Power Transmission.* Catalog 1050., 4th ed., copyright 1965, p. 251.

INFORMATION SHEET

VI. Types of lubricators (Transparencies 1-4)

A. Hand oil can

B. Pump-type oil can

C. T-handle pressure grease gun

D. Automatic air-powered grease gun

E. Lever-type pressure gun

F. Drop-feed oiler

G. Pressure activated drop-feed oiler

H. Thermal oiler

I. Vibrating pin bottle oiler

J. Constant level oiler

K. Chain oiler

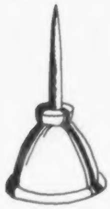
L. Fixed-collar oiler

M. Bath lubrication

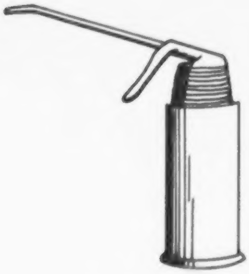
N. Oil mist lubrication

O. Central lubrication system

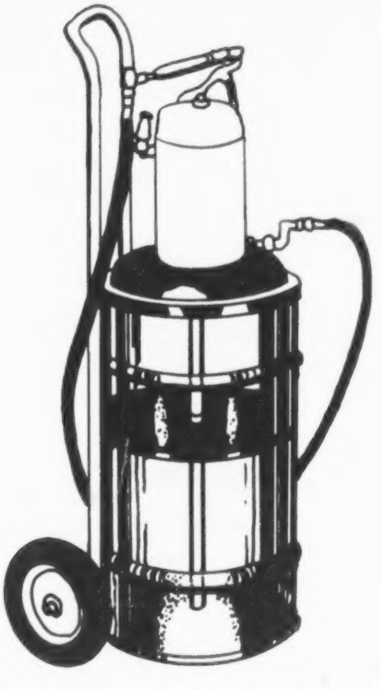
Types of Lubricators



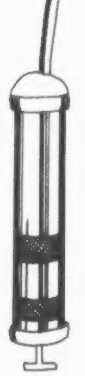
Hand Oil Can



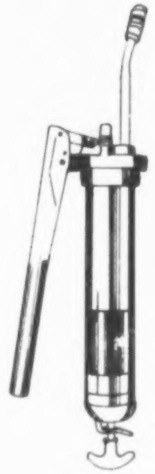
Pump-Type
Oil Can



Automatic Air-Powered
Grease Gun



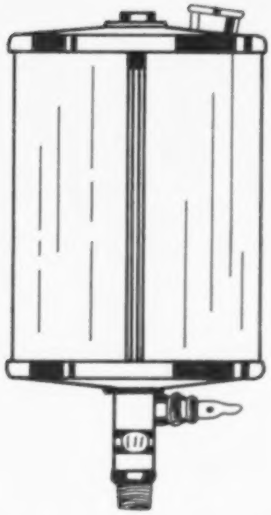
T-Handle Pressure
Grease Gun



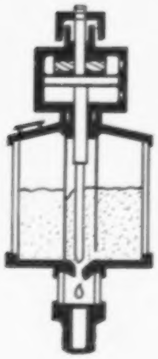
Lever-Type
Pressure Gun

Types of Lubricators

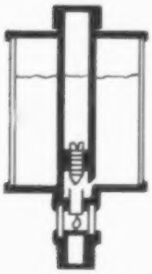
(Continued)



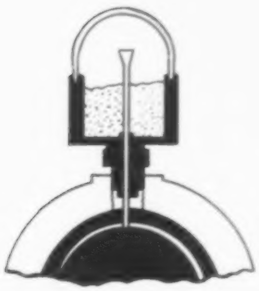
Drop-Feed Oiler



Pressure Activated
Drop-Feed Oiler



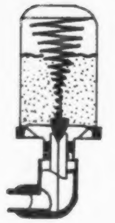
Thermal Oiler



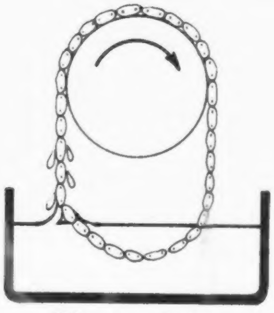
Vibrating Pin
Bottle Oiler

Types of Lubricators

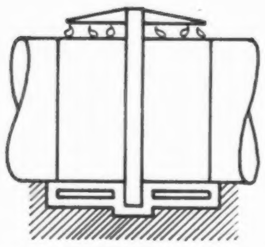
(Continued)



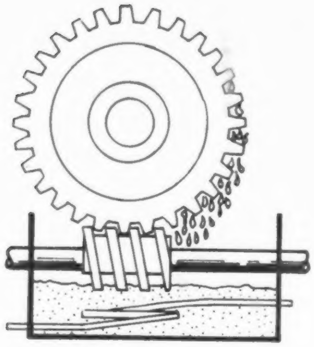
Constant Level Oiler



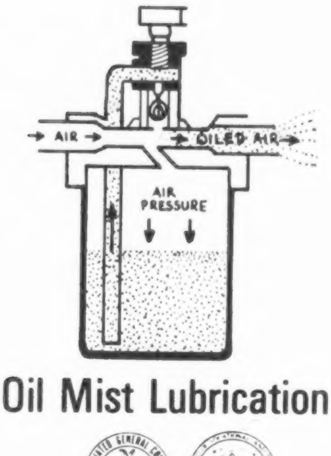
Chain Oiler



Fixed-Collar Oiler



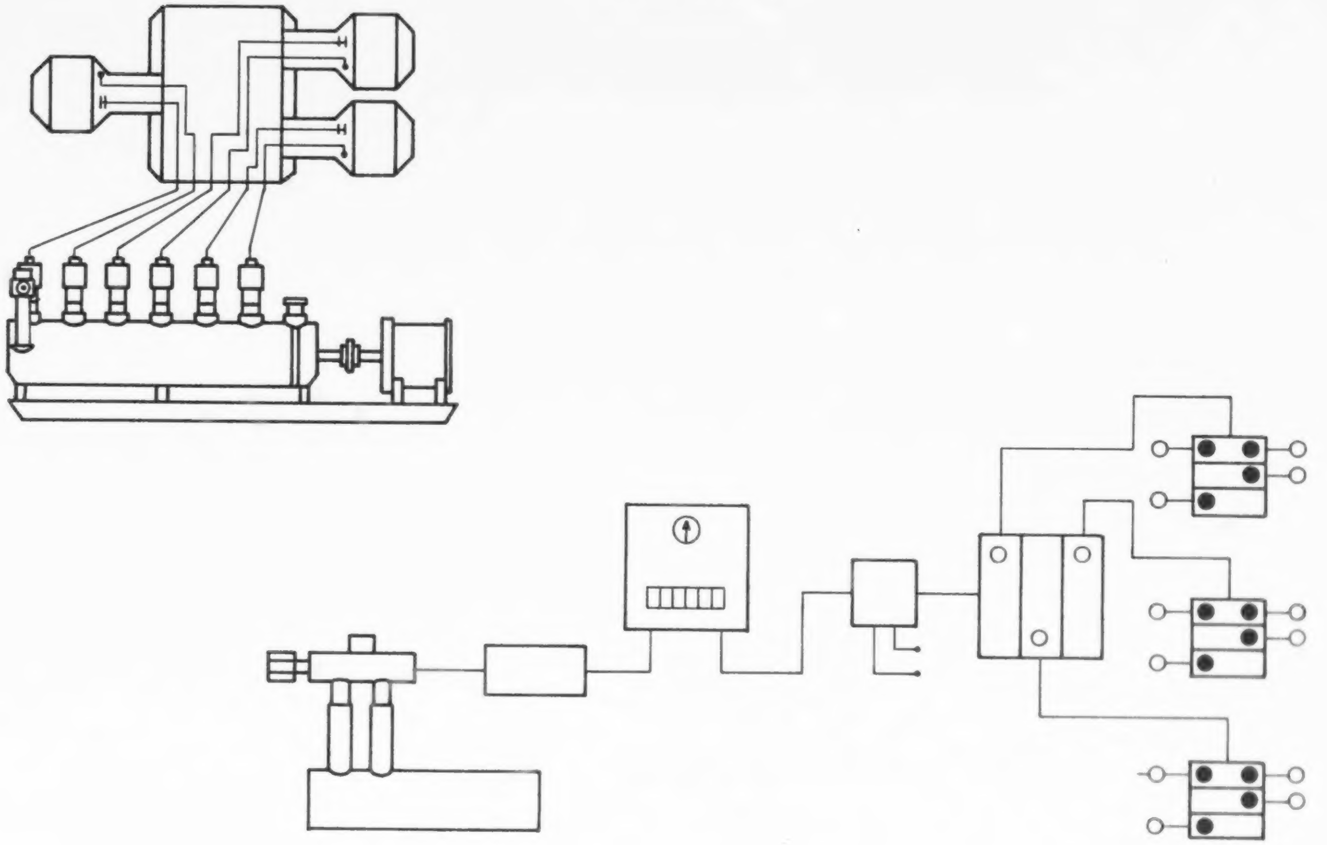
Bath Lubrication


AIR
OILED AIR
AIR PRESSURE

Oil Mist Lubrication

Types of Lubricators

(Continued)



Central Lubrication System

GEAR BOXES AND SPEED REDUCERS
UNIT V

TEST

NAME ________________________________ SCORE ________________

1. Match terms associated with gear boxes and speed reducers to the correct definitions. Place the correct numbers in the blanks provided.

   _____a. Device which provides simple, quick, and precise speed control to meet varying requirements

   _____b. Related to or having the form of a helix

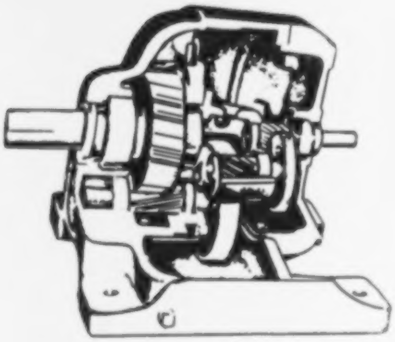
   _____c. Object having spiral form

   _____d. Power coupling which operates on a hydraulic turbine principle

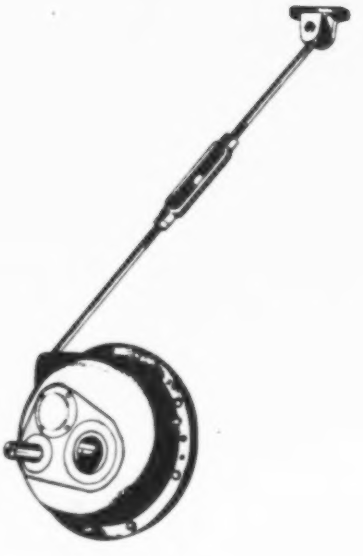
   _____e. Resembling a cone in shape

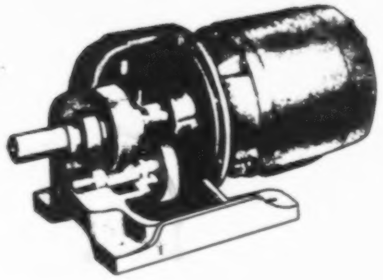
   1. Helical
   2. Conical
   3. Fluid drive
   4. Variable speed drive
   5. Helix

2. Identify the basic types of gear boxes and speed reducers in the following illustrations. Write the correct names in the blanks provided.



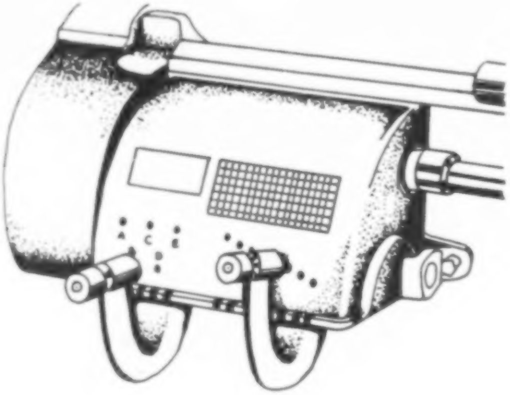
a. ________________________________

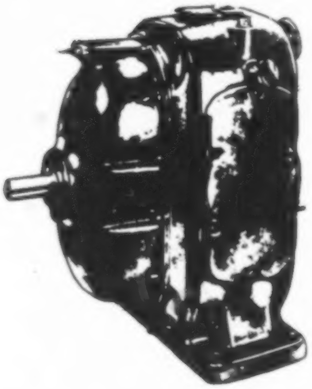




b. ______________________________

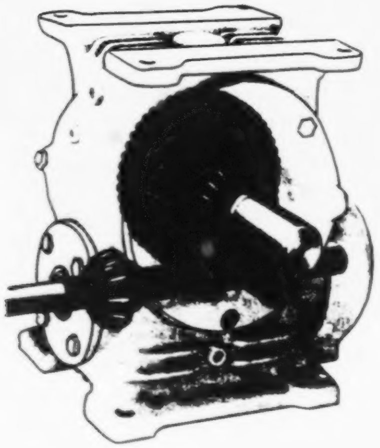
c. ______________________________



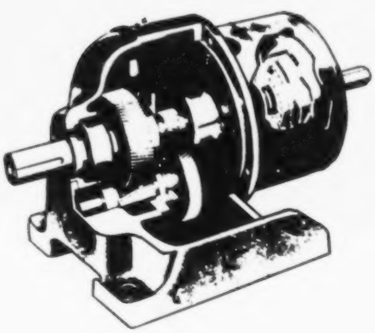


d. ______________________________

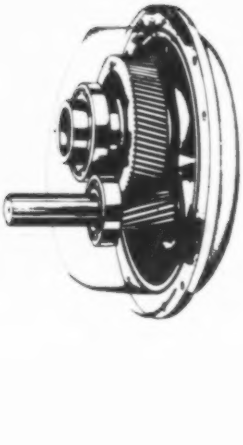
e. ______________________________



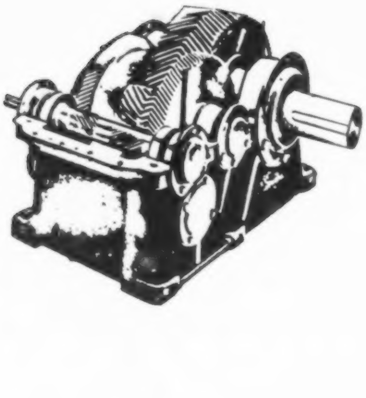
f. ____________________



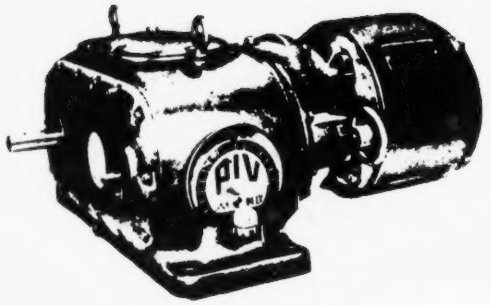
g. ____________________

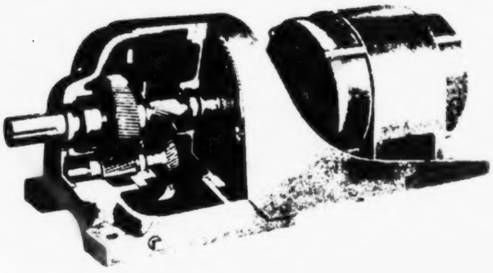


h. ____________________



i. ____________________





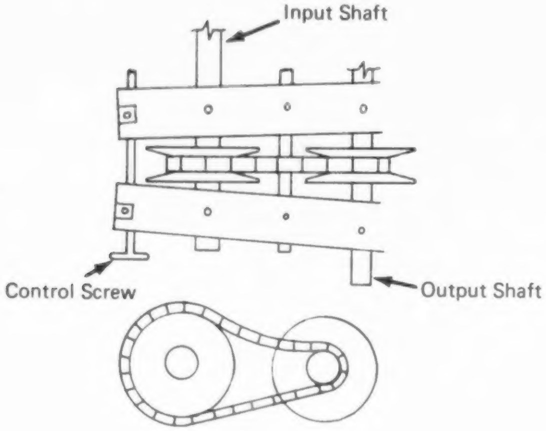
j. ____________________ k. ____________________

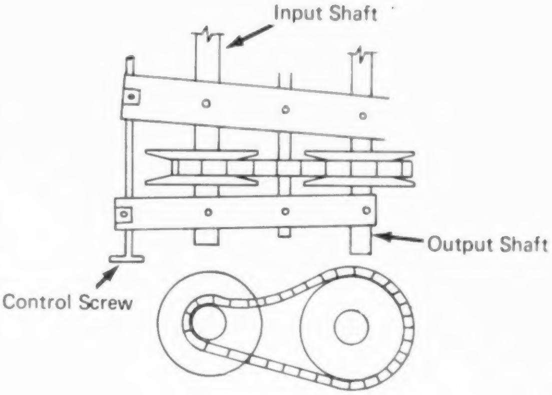
3. List four specific uses of variable speed drives.
   a. ____________________
   b. ____________________
   c. ____________________
   d. ____________________

4. Describe the advantage of variable speed drives.

   ____

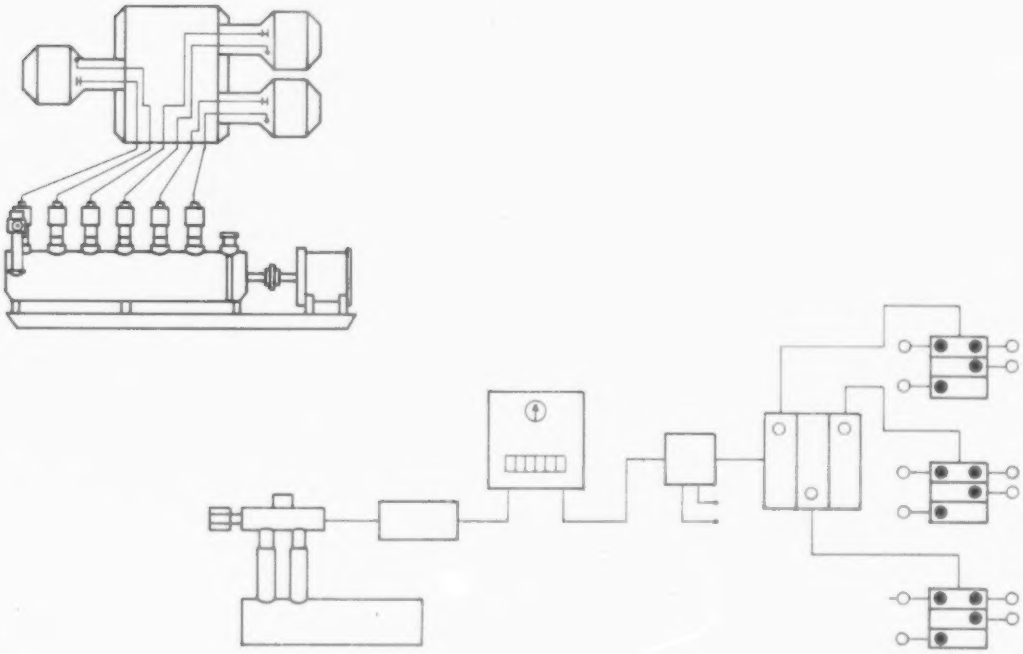
5. Select from the following illustrations the speed setting for maximum speeds. Place an "X" in the correct blank.


Input Shaft
Control Screw
Output Shaft

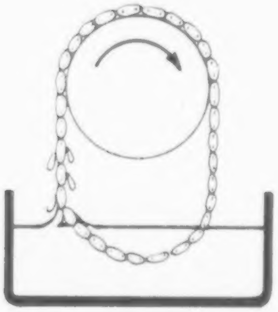

Input Shaft
Output Shaft
Control Screw

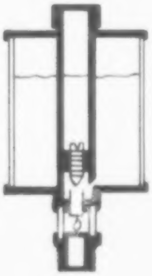
a. ________ b. ________

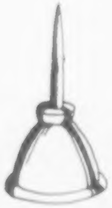
6. Identify types of lubricators in the following illustrations. Place the correct names in the blanks provided.



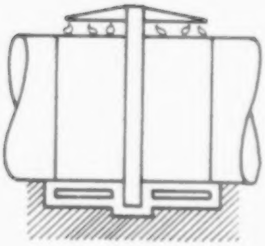
a. ______________________________

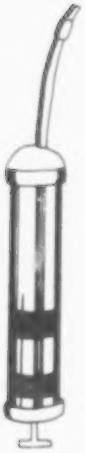




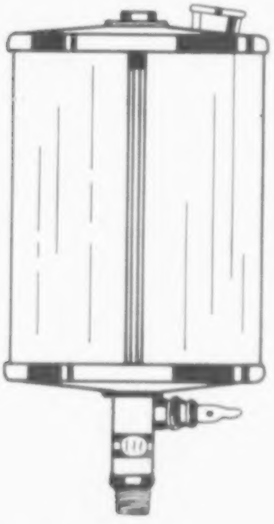


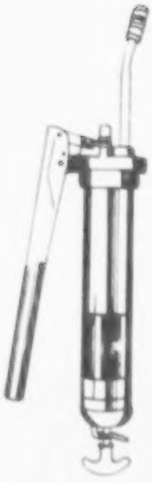
b. ________________ c. ________________ d. ________________



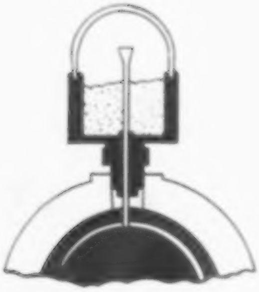


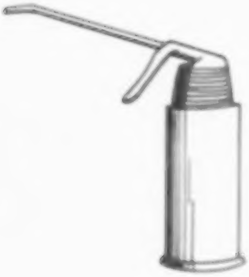
e. ______________________________ f. ______________________________





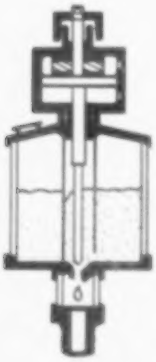
g. ______________________________ h. ______________________________

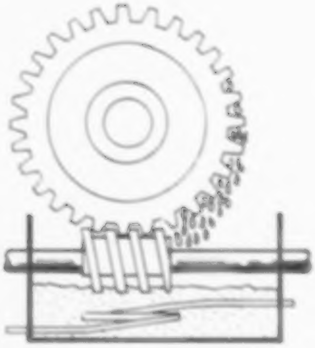




i. ______________________

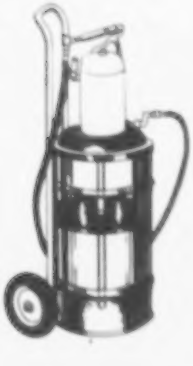
j. ______________________

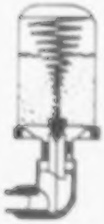


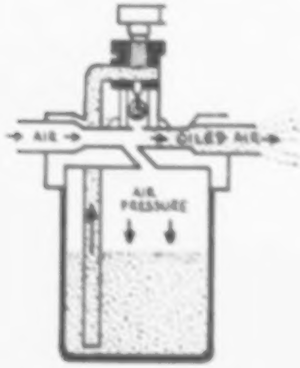


k. ______________________

l. ______________________






AIR
OILED AIR
AIR PRESSURE

m. ______________

n. ______________

o. ______________

GEAR BOXES AND SPEED REDUCERS
UNIT V

ANSWERS TO TEST

1. a. 4
   b. 1
   c. 5
   d. 3
   e. 2
2. a. In-line helical gear speed reducer
   b. Shaft-mounted speed reducer
   c. Gear motor
   d. Quick change gear box
   e. Variable speed drives
   f. Worm gear speed reducer
   g. Fluid gear drive
   h. Shaft mounted speed reducer
   i. Parallel shaft speed reducer
   j. Variable speed drive with integrally mounted motor
   k. Motogear
3. Any four of the following:
   a. Timing of processes
   b. Controlling length on all types of shears and cutters
   c. Output on various types of handling systems
   d. Production of various sizes, shapes, grades, and quantities of products on a single machine
   e. Winding materials on rolls at constant linear speed
   f. Synchronizing related machine components
4. Infinite speed variation

5. a
6. a. Central lubrication system
   b. Chain oiler
   c. Thermal oiler
   d. Hand oil can
   e. Fixed collar oiler
   f. T-handle pressure grease gun
   g. Drop-feed oiler
   h. Lever-type pressure gun
   i. Vibrating pin bottle oiler
   j. Pump-type oil can
   k. Pressure activated drop-feed oiler
   l. Bath lubrication
   m. Automatic air-powered grease gun
   n. Constant level oiler
   o. Oil mist lubrication

COUPLINGS, GEARS, AND DRIVES
UNIT VI

UNIT OBJECTIVE

After completion of this unit, the student should be able to recognize different types of couplings, gears, and drives. The student should also be able to align couplings and a pulley and/or sprocket. This knowledge will be evidenced by completion of the job sheets and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with couplings, gears, and drives to the correct definitions.
2. Distinguish between basic types of couplings.
3. Identify specific types of couplings.
4. Distinguish between true alignment and misalignment.
5. Select from a list methods used to align couplings.
6. Identify the formula used to determine angular alignment of couplings.
7. Identify types of gears.
8. Select 20° and 14.5° pressure angles.
9. Select from a list advantages of the 20° pressure angle.
10. Distinguish between circular pitch and diametral pitch.
11. Identify parts of a circular gear.
12. Select from a list reasons for backlash in gear drives.
13. Name advantages of herringbone gears.
14. Describe a gear set and a gear train.
15. Distinguish between speed advantage and mechanical advantage.
16. Describe gear ratio.
17. List major systems used for transmission of rotary motion between adjacent shafts.

18. List types of belts.
19. Describe multiple belt drive.
20. Distinguish between results of belt tension that is too loose or too tight.
21. Identify types of chains used for power transmission.
22. Identify parts of a roller chain.
23. Complete a chart on various center distances to obtain proper sag.
24. Demonstrate the ability to:
    a. Align coupling using dial indicator.
    b. Use thickness gage and straight edge for vertical, angular, and horizontal alignment.
    c. Align pulley and/or sprocket.

COUPLINGS, GEARS, AND DRIVES
UNIT VI

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide student with objective sheet.

  B. Provide student with information and job sheets.

  C. Make transparencies.

  D. Discuss unit and specific objectives.

  E. Discuss information sheet.

  F. Demonstrate and discuss procedures outlined in job sheets.

  G. Give test.

II. Instructional materials:

  A. Objective sheet

  B. Information sheet

  C. Transparency masters

    1. TM 1--Types of Couplings
    2. TM 2--Types of Couplings (Continued)
    3. TM 3--Types of Couplings (Continued)
    4. TM 4--Types of Couplings (Continued)
    5. TM 5--Types of Gears
    6. TM 6--Types of Gears (Continued)
    7. TM 7--Parts of a Circular Gear
    8. TM 8--Types of Belts
    9. TM 9--Types of Chains
    10. TM 10--Types of Chains (Continued)
    11. TM 11--Parts of a Roller Chain

D. Job sheets:

1. Job Sheet #1--Align Coupling Using Dial Indicator
2. Job Sheet #2--Use Thickness Gage and Straight Edge for Vertical, Angular, and Horizontal Alignment
3. Job Sheet #3--Align Pulley and/or Sprocket

E. Test

F. Answers to test

III. Unit references:

A. Nelson, Carl A. *Millwrights' and Mechanics' Guide.* 2nd ed. Indianapolis, Indiana: Howard W. Sams and Co., Inc., 1978.

B. *Maintenance Millwright I: Training Module.* Houston, Texas: Brown and Root, Inc. n.d.

COUPLINGS, GEARS, AND DRIVES
UNIT VI

INFORMATION SHEET

I. Terms and definitions

A. Coupling--Device for connecting two coaxial shafts so one shaft can drive the other shaft

B. Gear--Form of disc or wheel with teeth around perimeter to provide positive drive by meshing teeth with similar teeth on another gear

C. Sheave--Grooved wheel or rim used to transmit power by means of a belt, chain, rope, or band over its rim

D. Pressure angle--Angle formed by sides of a tooth inclining upward at an angle toward the center

E. Zero indicator--Adjustment of an indicator to read zero

F. Run-out--Amount of misalignment on a rotating shaft as read by an indicator

G. Sprocket--Toothed wheel shaped so as to engage with a chain

H. Addendum--Distance tooth projects above or outside the pitch line of circle

I. Dedendum--Depth of tooth space below or inside the pitch line of circle

J. Clearance--Amount the dedendum of a gear tooth exceeds the addendum of a mating gear tooth

K. Whole depth--Total depth of tooth space

L. Working depth--Depth of tooth engagement between two mating gears

M. Tooth thickness--Distance from one side of gear tooth to other side of gear tooth at the pitch circle

N. Backlash--Play between teeth that prevents binding

O. Idler gear--Small gear used between two excessively larger gears when required by shaft spacing; also used to change direction of rotation

P. Feeler bars--Bars or rods (wood or metal) of equal lengths used to check parallel of shafts

Q. Alignment--Proper positioning of equipment

INFORMATION SHEET

R. Pulley--Wheel or rim with flat surface; used to transmit power

S. Pitch line (pitch circle)--Distance from a point on one tooth to a corresponding point on the next tooth; measured along the pitch line or circle

II. Basic types of couplings

A. Flexible--Transmits power and positive rotation on coaxial shafts of independent units; used to correct slight misalignments

B. Rigid--Provides a fixed union between shafts when true alignment and rigidity are required

III. Specific types of couplings (Transparencies 1-4)

A. Flexible

1. Slider
2. Gear
3. Chain
4. Bellows
5. Rubber-flex
6. Air-flex
7. Dowel-drive
8. Lug-drive
9. U-joint
10. Steel grid
11. Floating
12. Spacer
13. Coupling with tapered bushing

B. Rigid

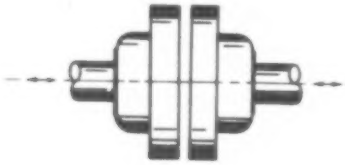
1. Clamp or ribbed
2. Flange
3. Compression

INFORMATION SHEET

IV. Types of alignment

A. True alignment

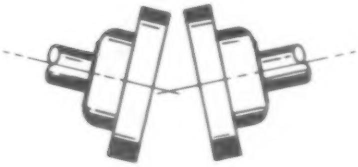
(NOTE: This occurs when perfect angular and parallel alignment and true fit of the mating surfaces are achieved.)



B. Misalignment

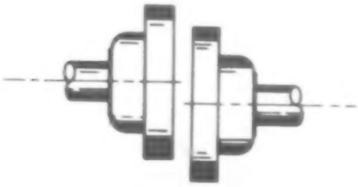
1. Angular misalignment

(NOTE: These are not properly aligned angularly in any plane through 360 degrees.)



2. Parallel misalignment

(NOTE: These are parallel but not in a true line with each other.)



V. Methods used to align couplings

A. Dial indicator

B. Straightedge and feeler gage

INFORMATION SHEET

VI. Formula used to determine angular alignment of couplings (Job Sheets #1, #2, and #3)

(NOTE: This formula will correct angular misalignment but will not affect parallel misalignment.)

A. Width--A x B = X

B. Dimension--X÷ D = amount for front foot

C. Width--A x C = Z

D. Dimension--Z÷ D = amount for back foot

(NOTE: Add shims if narrow on bottom; subtract shims if wide on bottom.)

Example: A = 0.005" (widest dimension between couplings)

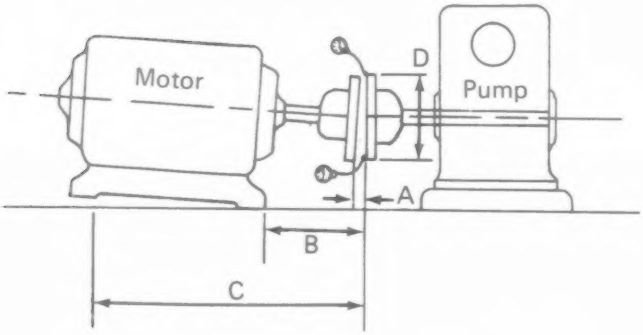
B = 4.5" (dimension from stationary coupling to front of front leg)

C = 12" (dimension from stationary coupling to front of rear leg)

D = 4" (width of coupling)

Front foot = 0.005" x 4.5" = 0.0225"÷ 4 = 0.0056"
(Subtract 0.005" shims from front foot)

Back foot = 0.005" x 12.5" = 0.0625"÷ 4 = 0.0156"
(Subtract 0.015" shims from back foot)



INFORMATION SHEET

VII. Types of gears (Transparencies 5 and 6)

A. Spur

(NOTE: This is the basic gear from which all other gears are derived.)

B. Straight line

C. Pinion

(NOTE: The smaller of a pair of gears is often called a *pinion gear*.)

D. Idler

(NOTE: This is the common name for any small gear used between larger main gears.)

E. Bevel

F. Miter

G. Miter with spiral teeth

H. Helical

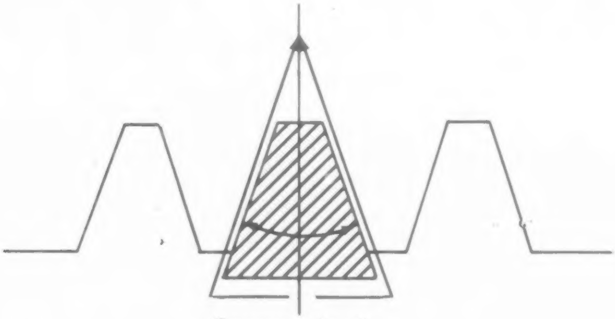
I. Typical spiral

J. Worm

K. Herringbone

VIII. Pressure angle

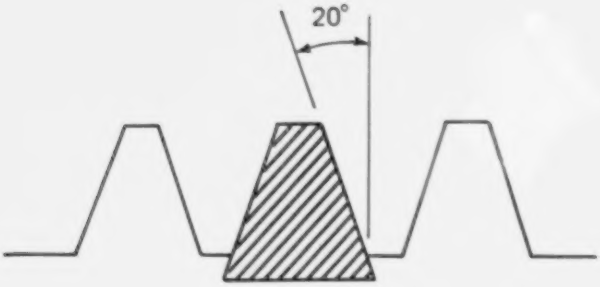
(NOTE: The sides of each tooth inclining toward the center top at an angle is called the *pressure angle*.)



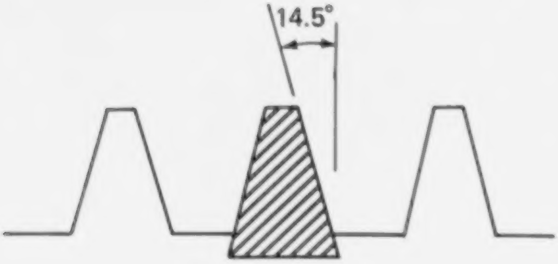
Pressure Angle

INFORMATION SHEET

A. 20° pressure angle



B. 14.5° pressure angle



(NOTE: The 14.5° pressure angle, which was standard for many years, has practically been replaced by the 20° pressure angle.)

IX. Advantages of 20° pressure angle

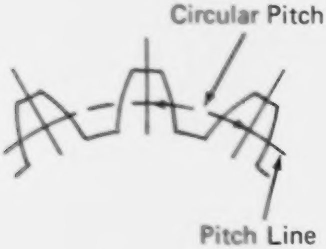
- A. Increases strength
- B. Increases wear resistance
- C. Permits pinions to be used with less teeth

INFORMATION SHEET

X. Specific types of pitch

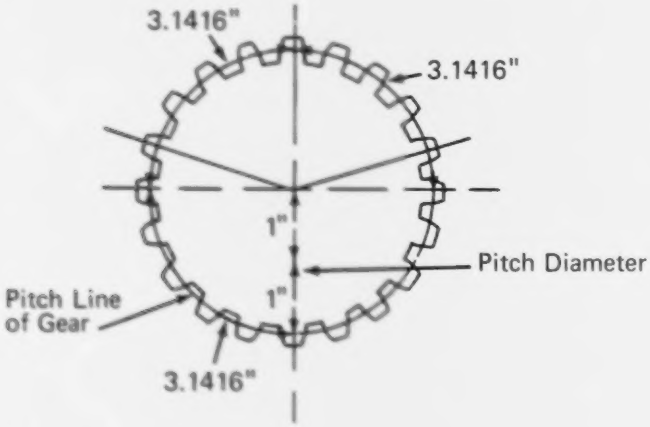
(NOTE: All corresponding gears must have the same tooth size.)

A. Circular pitch--Distance from a point on one tooth to a corresponding point on the next tooth; measured along pitch line


Circular Pitch
Pitch Line

B. Diametrial pitch--Designates size and proportions of gear teeth, specified by number of teeth in pi (π) (3.1416") along the pitch line of a gear

(NOTE: There are 3.1416" (π) of pitch line circumference for each inch of pitch diameter.)


3.1416"
3.1416"
1"
1"
Pitch Diameter
Pitch Line of Gear
3.1416"

XI. Parts of a circular gear (Transparency 7)

A. Addendum

B. Dedendum

C. Clearance

D. Whole depth

E. Working depth

INFORMATION SHEET

- F. Tooth thickness
- G. Root circle
- H. Hub
- I. Rim
- J. Bore

XII. Reasons for backlash in gear drives

- A. Provides running clearance
- B. Prevents binding of mating gears
- C. Prevents heat generation
- D. Prevents noise
- E. Prevents abnormal wear
- F. Prevents possible overload or failure of drive

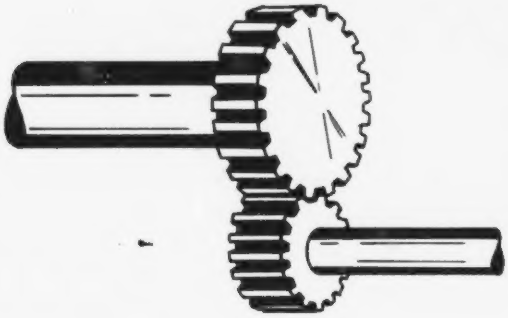
XIII. Advantages of herringbone gears

- A. Transmit power between parallel shafts
- B. Overcome high end-thrust present in helical gears

  (NOTE: The two sets of gear teeth cause the thrust of one gear to cancel out the thrust of the other gear.)

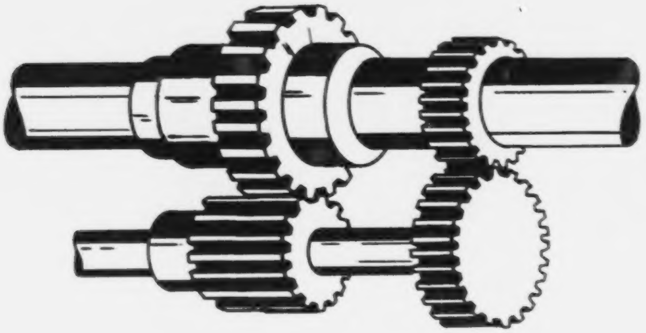
XIV. Gear set and gear train

- A. Gear set--Two gears that mesh together



INFORMATION SHEET

B. Gear train--Three or more engaged gears



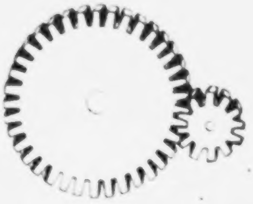
XV. Speed advantage and mechanical advantage

A. Speed advantage--Occurs when a small gear (pinion) is driven by a large gear; output shaft turns faster than input shaft

B. Mechanical advantage--Change in speed or force; occurs when large gear is driven by small gear

XVI. Gear ratio--Proportion of size of one gear in relation to size of another gear

(NOTE: Gear ratio can be calculated by the number of teeth in each gear or by the diameter of each gear.)



Examples: If diameter of drive gear is one-half of the driven gear, it must turn twice in order to turn the driven gear once; therefore, the ratio would be 2:1

If diameter of drive gear is twice twice that of the driven gear, it must turn once in order to turn driven gear two times; therefore, the ratio would be 1:2

If drive gear has 36 teeth and driven gear has 72 teeth, the drive gear would be one-half the size of the driven gear; therefore, the ratio would be 2:1

INFORMATION SHEET

XVII. Major systems used for transmission of rotary motion between adjacent shafts

   A. Belts

   B. Chains

   C. Gears

XVIII. Types of belts (Transparency 8)

   A. V-Belt

   B. Positive drive or gear belt

   C. Flat belt

XIX. Multiple belt drive--Several belts used together to transmit power

(NOTE: When installing multiple belts, they should be purchased in matched sets to prevent using belts that are not properly matched.)

XX. Results of belt tension that is too tight or too loose

   A. Too loose

      1. Slippage

      2. Unnecessary wear

      3. Excess vibration

      4. Loss of power

   B. Too tight

      1. Strained belts

      2. Strained shafts

      3. Strained bearings

XXI. Types of chains used for power transmission (Transparencies 9 and 10)

   A. Single-strand roller

   B. Multiple-strand roller

   C. Silent with middle guide

INFORMATION SHEET

- D. Silent or inverted-tooth
- E. Side flange silent
- F. Three-pitch silent
- G. Five-pitch silent

XXII. Parts of roller chain (Transparency 11)

- A. Pin link
- B. Roller link
- C. Pin link plate
- D. Roller link plate
- E. Roller
- F. Bushing
- G. Pin

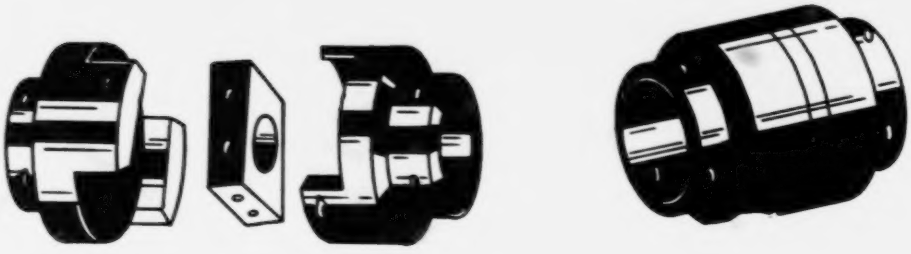
XXIII. Various center distances to obtain proper sag

(NOTE: This should be equal to two percent of the distance between shaft centers.)

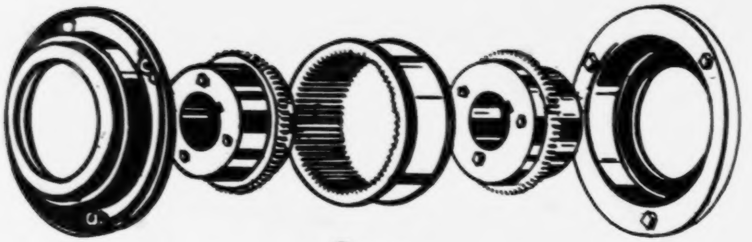
Shaft Centers	Sag	Shaft Centers	Sag
18"	3/8"	60"	1 1/4"
24"	1/2"	70"	1 1/2"
30"	5/8"	80"	1 5/8"
36"	3/4"	90"	1 7/8"
42"	7/8"	100"	2"
48"	1"	125"	2 1/2"
54"	1 1/8"		

Types of Couplings

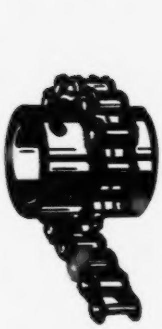
Flexible Couplings



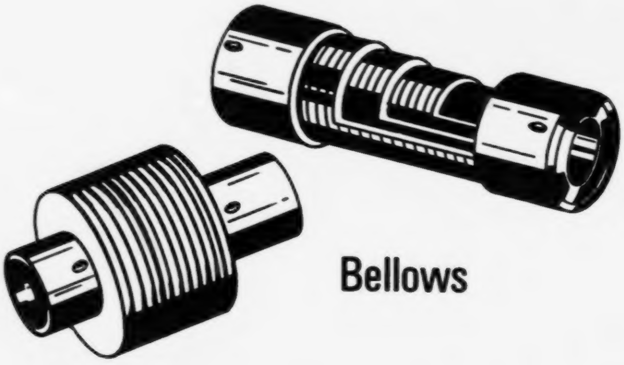
Slider



Gear



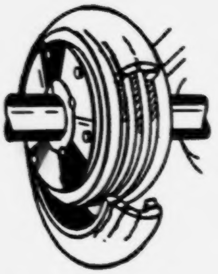
Chain



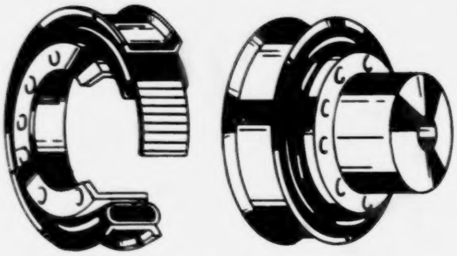
Bellows

Types of Couplings
(Continued)

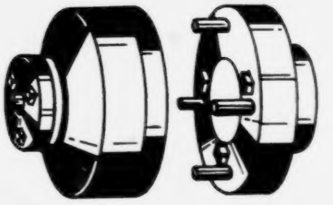
Flexible Couplings



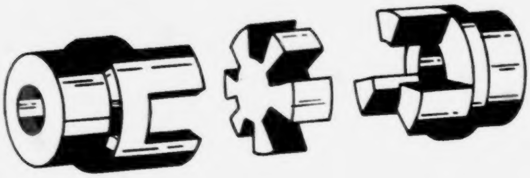
Rubber-Flex



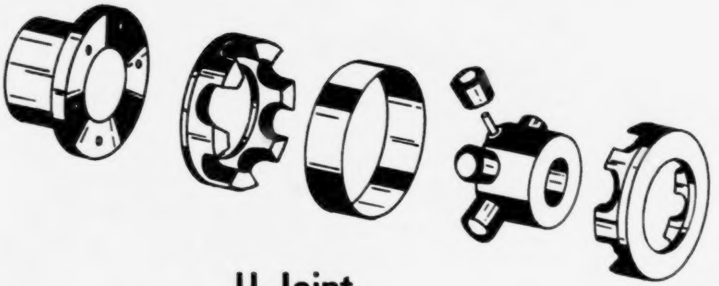
Air-Flex



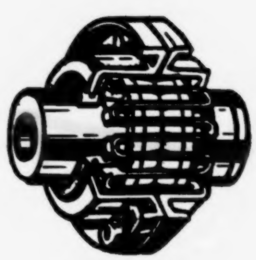
Dowel-Drive



Lug-Drive



U-Joint

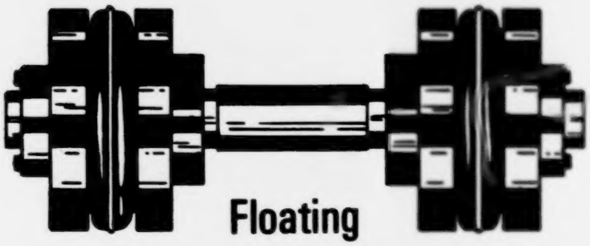


Steel Grid

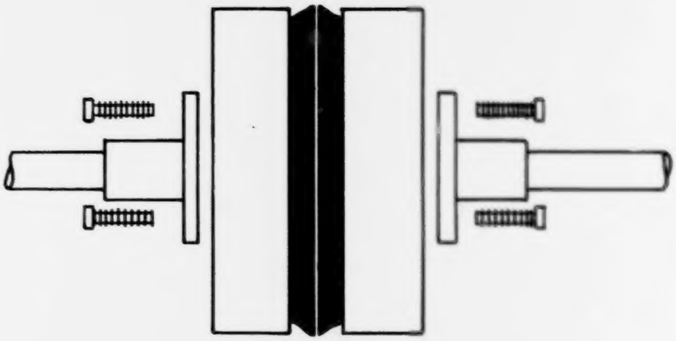
Types of Couplings

(Continued)

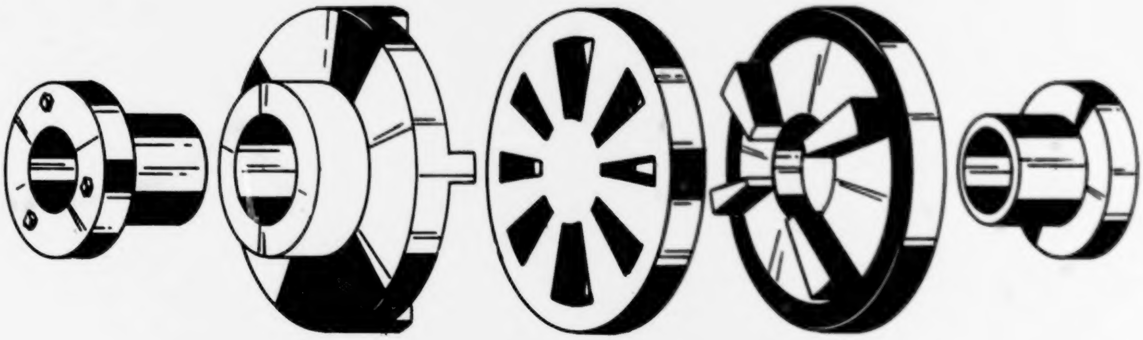
Flexible Couplings



Floating



Spacer

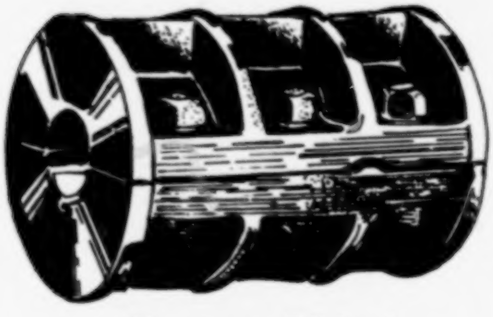


Coupling with Tapered Bushing

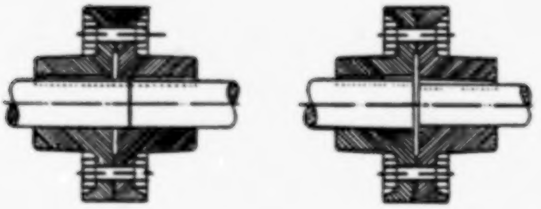
Types of Couplings

(Continued)

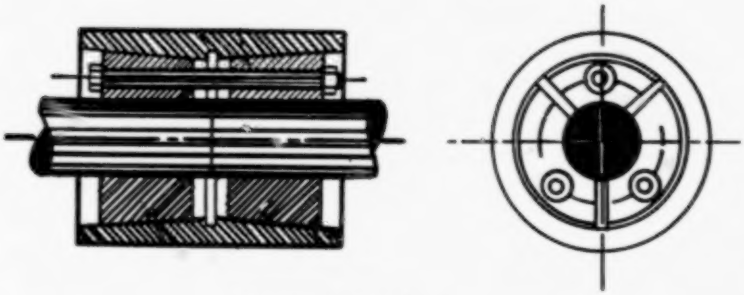
Rigid Couplings



Clamp or Ribbed

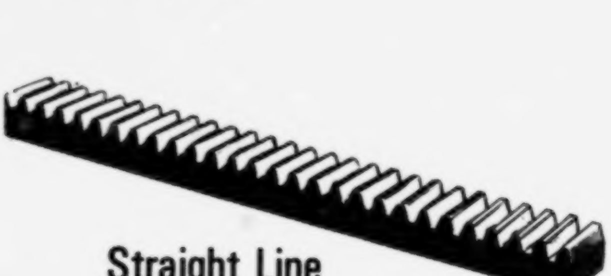


Flange

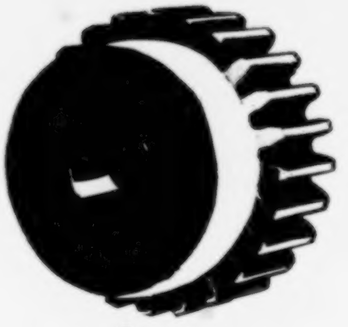


Compression

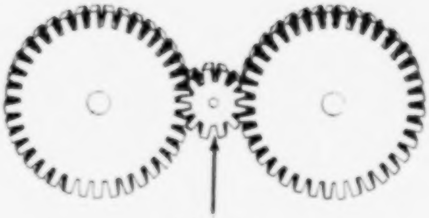
Types of Gears



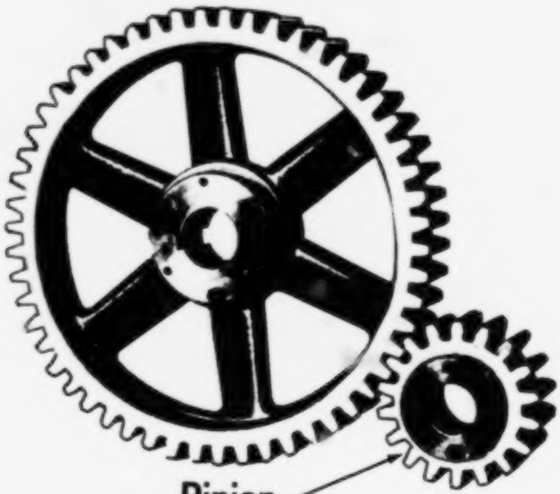
Straight Line



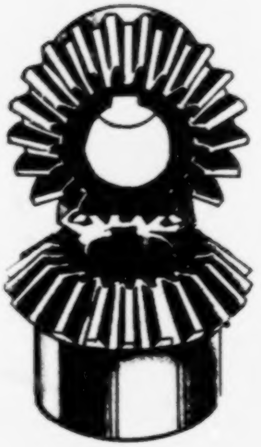
Spur



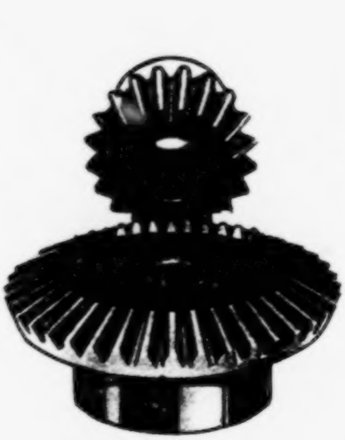
Idler



Pinion

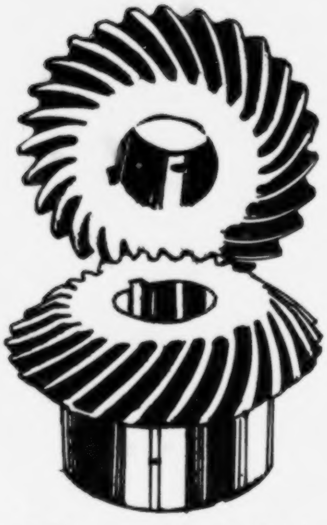


Miter

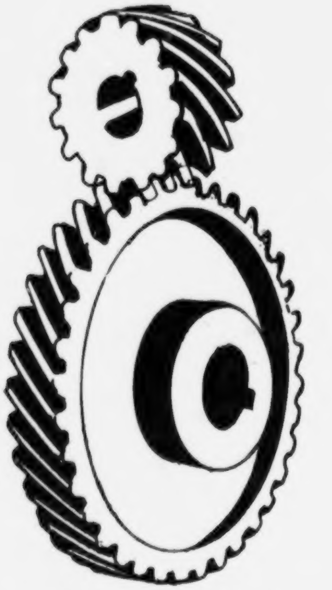


Bevel

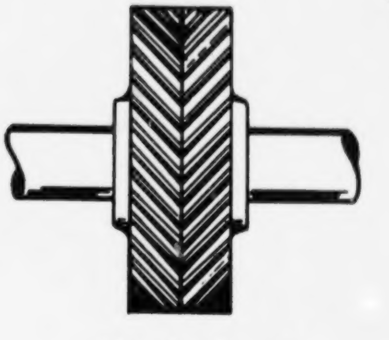
Types of Gears
(Continued)



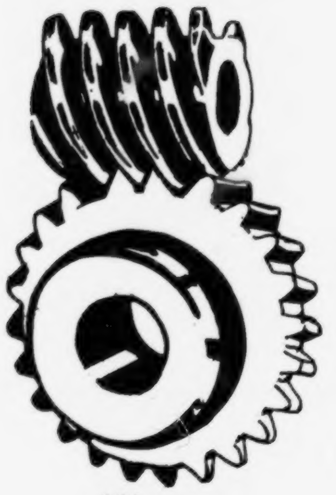
Miter with Spiral Teeth



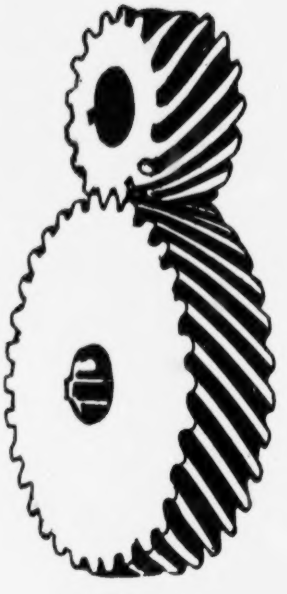
Typical Spiral



Herringbone

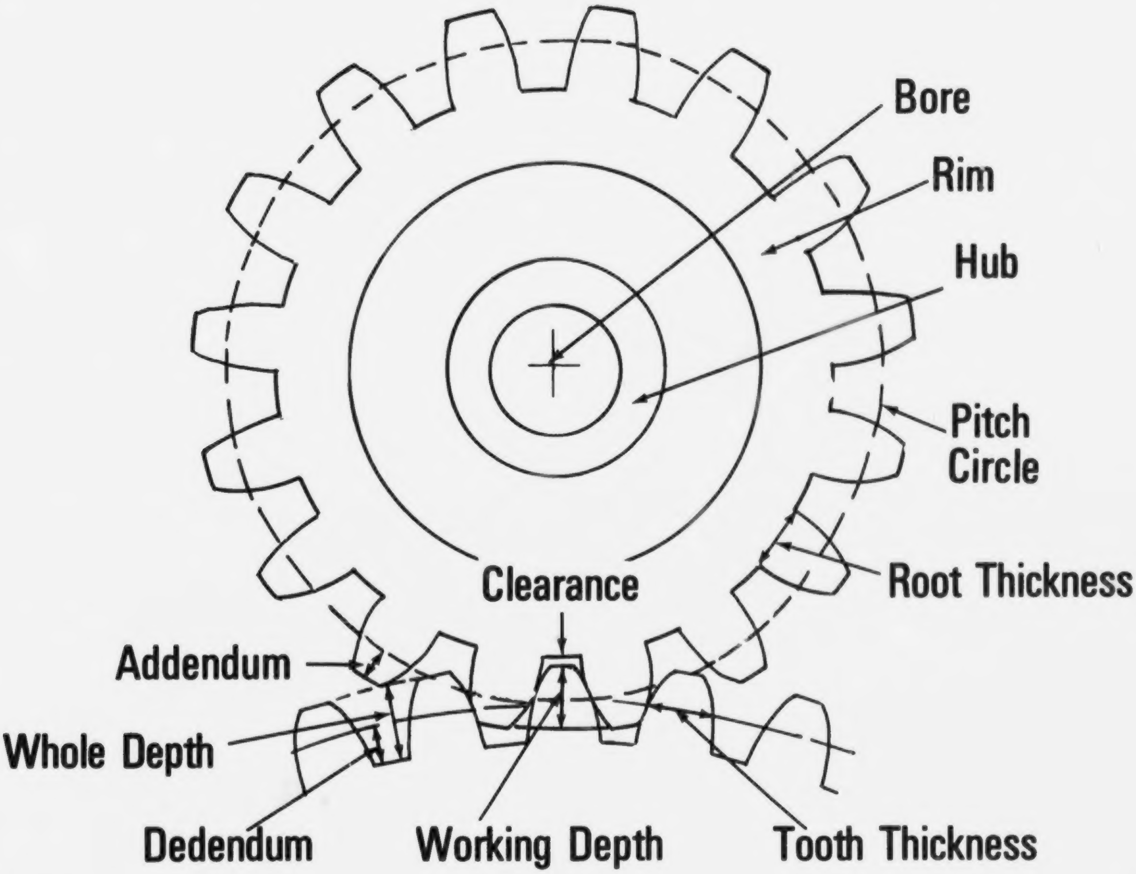


Worm

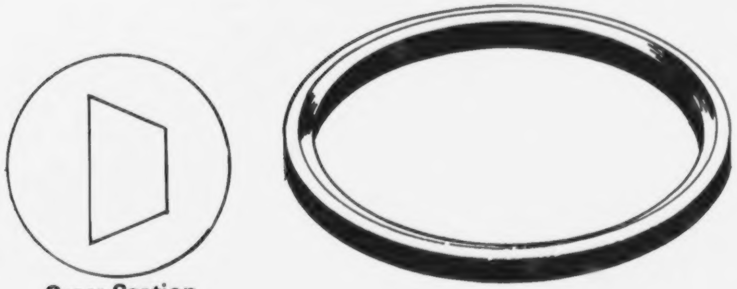


Helical

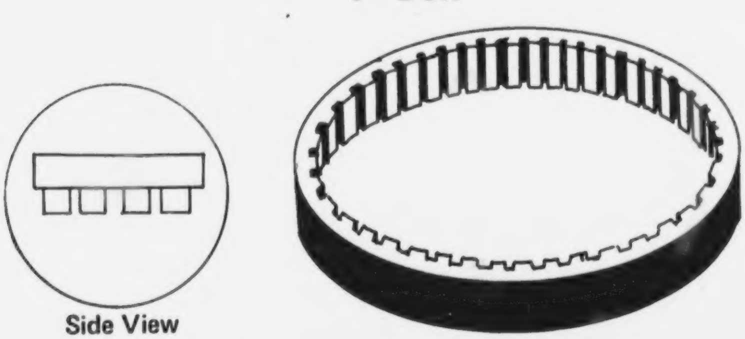
Parts of a Circular Gear


Bore
Rim
Hub
Pitch Circle
Root Thickness
Clearance
Addendum
Whole Depth
Dedendum
Working Depth
Tooth Thickness

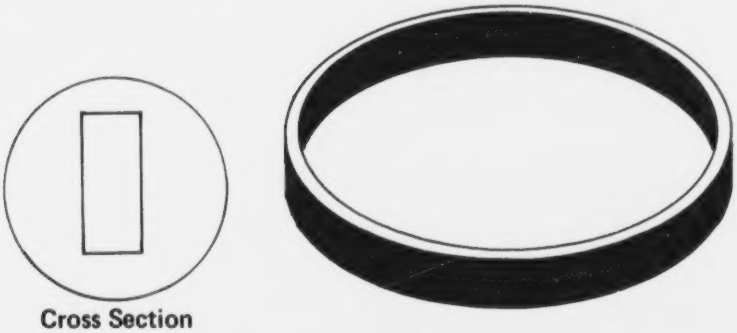
Types of Belts


Cross Section

V–Belt

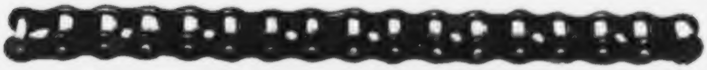


Positive Drive or Gear

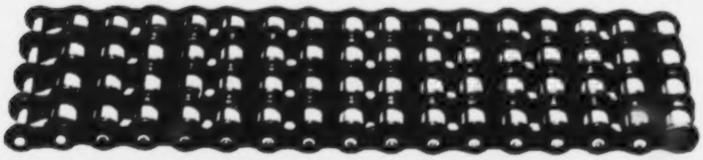

Cross Section

Flat

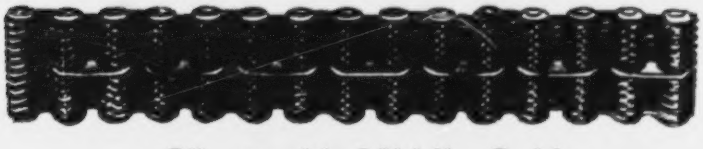
Types of Chains



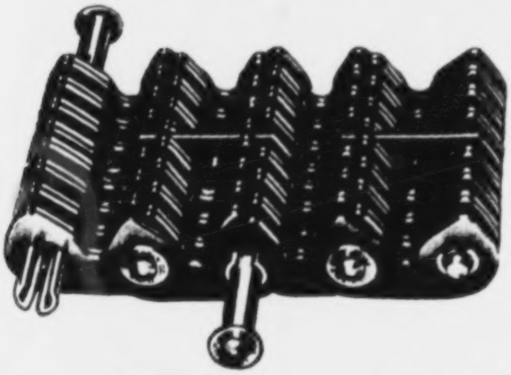
Single-Strand Roller



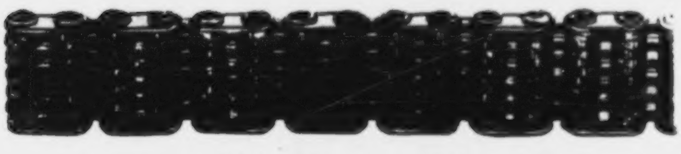
Multiple-Strand Roller



Silent with Middle Guide



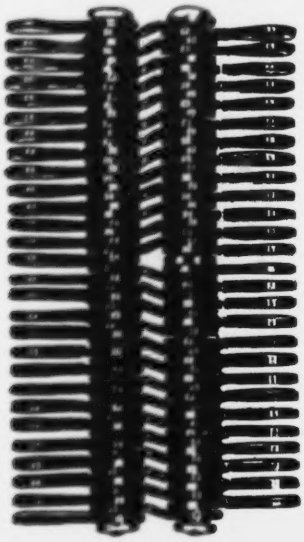
Silent or Inverted Tooth



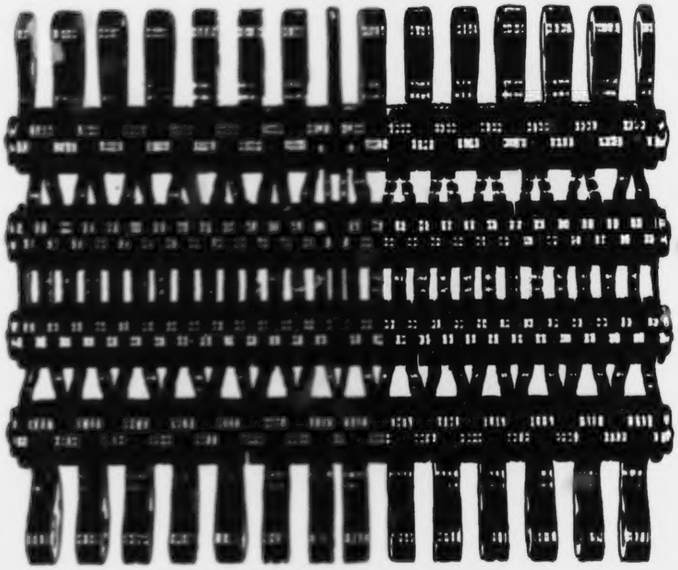
Side-Flange Silent

Types of Chains

(Continued)

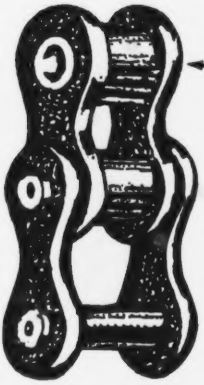


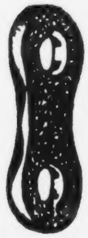
Three-Pitch Silent



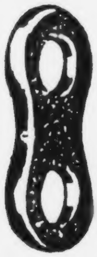
Five-Pitch Silent

Parts of a Roller Chain

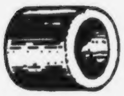

Roller Link
Pin Link



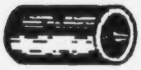
Pin Link Plate



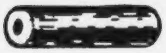
Roller Link Plate



Roller



Bushing



Pin

COUPLINGS, GEARS, AND DRIVES
UNIT VI

JOB SHEET #1--ALIGN COUPLING USING DIAL INDICATOR

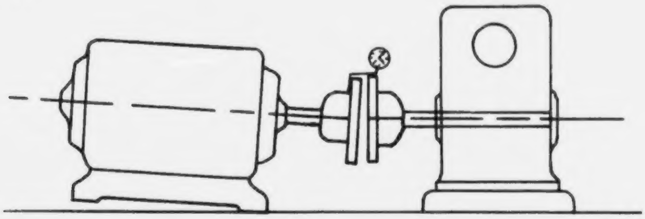
I. Tools and materials

- A. Motor and pump unit
- B. Coupling
- C. Dial indicator
- D. Tape
- E. Assorted wrenches
- F. Assorted shims
- G. Indicator bracket
- H. Mirror

II. Procedure:

- A. Attach indicator to motor coupling
- B. With indicator setting on top rim of pump coupling, zero indicator (Figure 1)

FIGURE 1

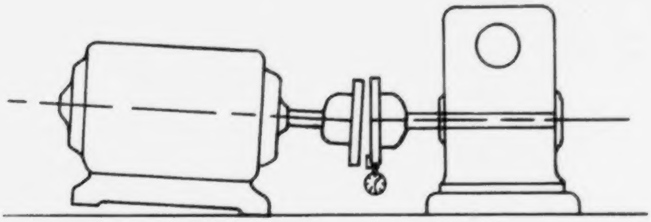


- C. Check each corner of motor for "soft foot"
- D. Adjust "soft foot" by shimming
- E. Zero indicator
- F. Roll indicator to bottom by rotating shaft

JOB SHEET #1

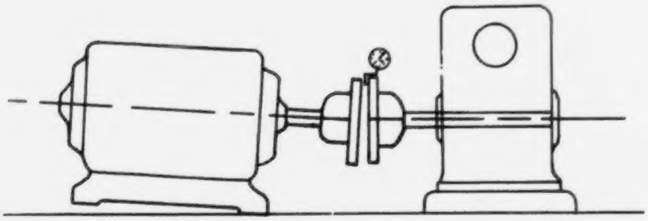
G. Use mirror to read amount of run-out on indicator (Figure 2)

FIGURE 2



H. Roll indicator back to top and mount on face of coupling (Figure 3)

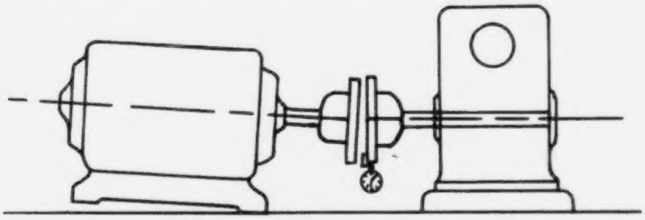
FIGURE 3



I. Zero indicator

J. Roll indicator to bottom and using mirror, read amount of run-out on indicator (Figure 4)

FIGURE 4



JOB SHEET #1

K. Use formula to adjust shim change

Formula

A. Front foot	B. Back foot
$A \times C = X$	$A \times D = Z$
$X \div E$ = Amount for front foot	$Z \div E$ = Amount for back foot

L. After vertical alignment is achieved, adjust motor until horizontal alignment is achieved

COUPLINGS, GEARS, AND DRIVES
UNIT VI

JOB SHEET #2--USE THICKNESS GAGE AND STRAIGHT EDGE FOR VERTICAL, ANGULAR, AND HORIZONTAL ALIGNMENT

I. Tools and materials

   A. Motor and pump unit

   B. Coupling

   C. Tape

   D. Assorted wrenches

   E. Assorted shims

   F. Straight edge

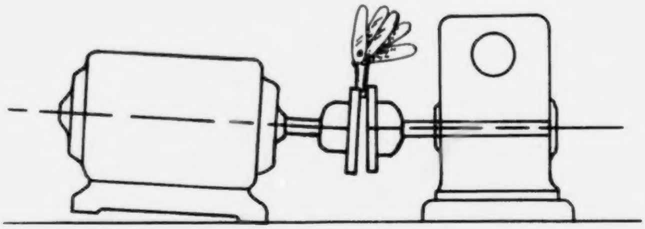
   G. Thickness gage

   H. Hydraulic jack

II. Procedure

   A. Use thickness gage to measure width of gap at top of coupling and record (Figure 1)

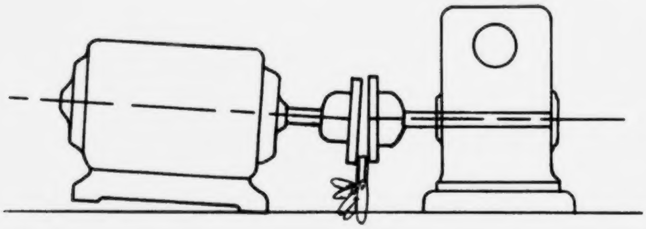
FIGURE 1



JOB SHEET #2

B. Use thickness gage to measure width of gap at bottom of coupling and record (Figure 2)

FIGURE 2



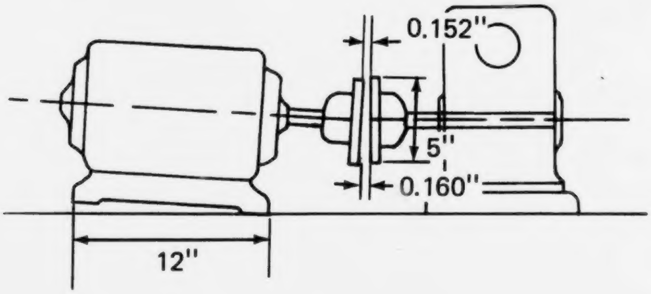
C. Figure difference between top and bottom gap to determine shim thickness to make correction

Formula:

Shim thickness will be as many times greater than the misalignment as the motor base length is greater than the coupling diameter

(NOTE: Shim under low end.)

Example:



1. (0.160" - 0.152") x 0.008" misalignment
2. Base length (12") is about 2 1/2 times the coupling diameter
3. 2 1/2 x 0.008" = 0.020"
4. Use 0.020" shims under low end

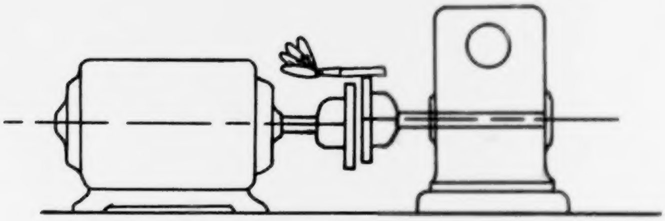
D. Place 0.020" shims under low end of motor and tighten hold-down bolts

JOB SHEET #2

E. After vertical alignment is accomplished, adjust motor until horizontal alignment is achieved

F. Measure height difference between motor and pump coupling on top surface of coupling (Figure 3)

FIGURE 3



G. Loosen hold-down bolts on motor

H. Place shims under all motor support points the same thickness as the measured height difference

I. Tighten down all hold-down bolts

J. Recheck angular and horizontal alignment

COUPLINGS, GEARS, AND DRIVES
UNIT VI

JOB SHEET #3--ALIGN PULLEY AND/OR SPROCKET

I. Materials and equipment

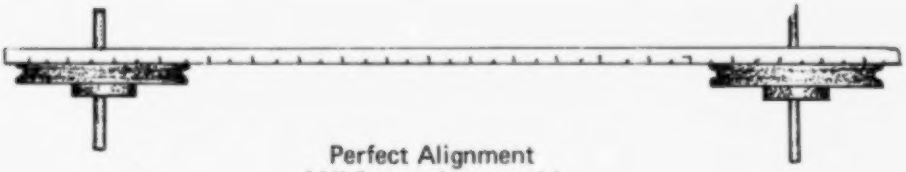
- A. Pulleys (sprockets) 2
- B. Dial indicator
- C. Straight edge or line
- D. Machinist's level
- E. Assorted wrenches and/or screwdrivers

II. Procedure

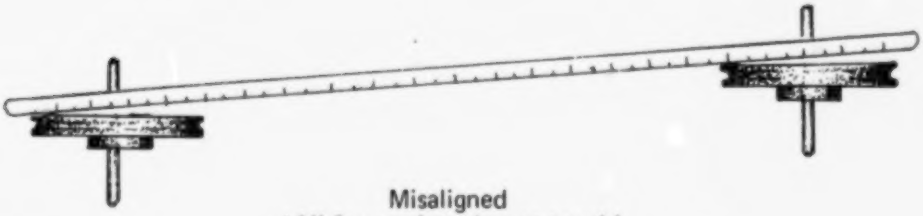
- A. Check pulley or sprocket to be sure key has been inserted and it is securely fastened to the shaft
- B. Use a straight edge to make sure pulleys or sprockets are exactly opposite each other (Figure 1)

  (NOTE: A string may be used to check instead of a straightedge.)

FIGURE 1



Perfect Alignment
(All four points touch)



Misaligned
(All four points do not touch)

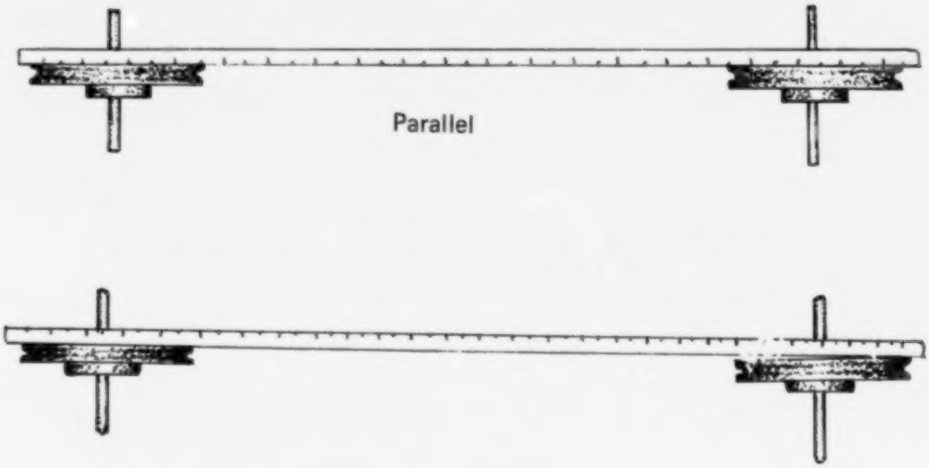
JOB SHEET #3

C. Loosen lock screw and slide pulley along shaft until in alignment; tighten lock screw

D. Use a straightedge to make sure pulley is in exact line; if so, shafts will be parallel (Figure 2)

(NOTE: This may also be done with micrometers or feeler bars.)

FIGURE 2

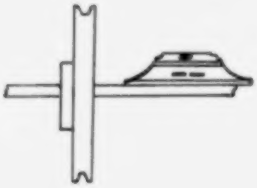


Not Parallel

E. Loosen anchor bolts and shift unit slightly to correct parallel alignment; retighten anchor bolts

F. Use machinist's level to check to see that shafts are level (Figure 3)

FIGURE 3



COUPLINGS, GEARS, AND DRIVES
UNIT VI

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with couplings, gears, and drives to the correct definitions. Place the correct numbers in the blanks provided.

_____a. Device for connecting two coaxial shafts so one shaft can drive the other shaft

_____b. Form of disc or wheel with teeth around perimeter to provide positive drive by meshing teeth with similar teeth on another gear

_____c. Grooved wheel or rim used to transmit power by means of a belt, chain, rope, or band over its rim

_____d. Angle formed by side of a tooth inclining upward at an angle toward the center

_____e. Adjustment of an indicator to read zero

_____f. Amount of misalignment on a rotating shaft as read by an indicator

_____g. Toothed wheel shaped so as to engage with a chain

_____h. Distance tooth projects above or outside the pitch line of a circle

_____i. Depth of tooth space below or inside the pitch line of a circle

_____j. Amount the dedendum of a gear tooth exceeds the addendum of a mating gear tooth

_____k. Total depth of tooth space

_____l. Depth of tooth engagement between two mating gears

_____m. Distance from one side of gear tooth to other side of gear tooth at the pitch circle

_____n. Play between teeth that prevents binding

1. Clearance
2. Pressure angle
3. Working depth
4. Coupling
5. Dedendum
6. Run-out
7. Addendum
8. Zero indicator
9. Sheave
10. Whole depth
11. Gear
12. Sprocket
13. Tooth thickness
14. Backlash

______o. Small gear used between two excessively larger gears when required by shaft spacing; also used to change direction of rotation

______p. Bars or rods (wood or metal) of equal lengths used to check parallel of shafts

______q. Proper positioning of equipment

______r. Wheel or rim with flat surface; used to transmit power

______s. Distance from a point on one tooth to a corresponding point on the next tooth; measured along the pitch line or circle

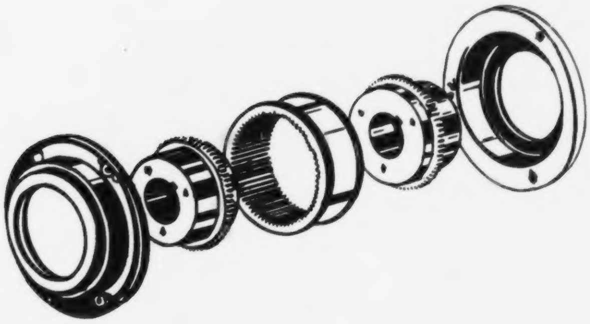
15. Feeler bars
16. Idler gear
17. Alignment
18. Pulley
19. Pitch line

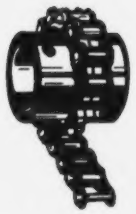
2. Distinguish between basic types of couplings. Place an "F" in the blank before the statement describing flexible couplings and an "R" before the statement describing rigid couplings.

   ______a. Provides a fixed union between shafts when true alignment and rigidity are required

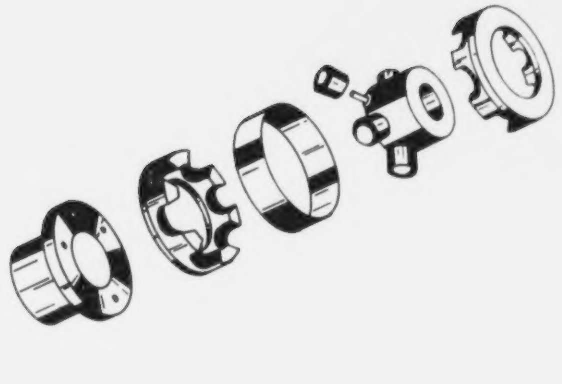
   ______b. Transmits power and positive rotation on coaxial shafts of independent units; used to correct slight misalignments

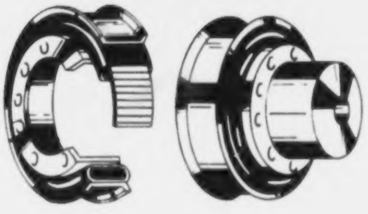
3. Identify specific types of couplings in the following illustrations. Write the correct names in the blanks provided.



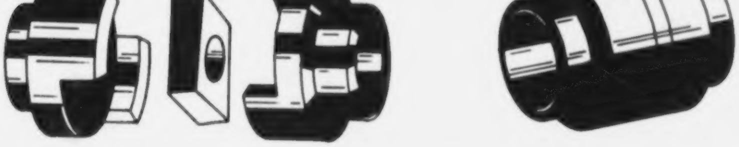


a. ______________________________ b. ____________________

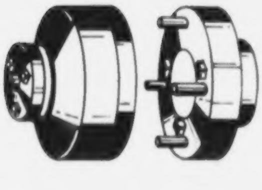


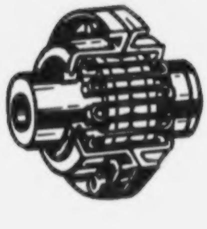


c. ______________________________ d. ______________________________

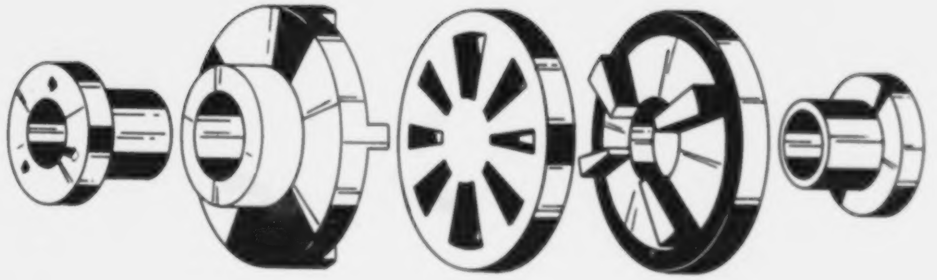


e. ______________________________

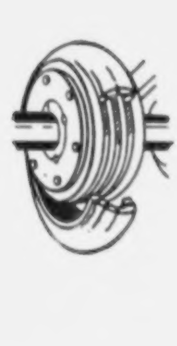


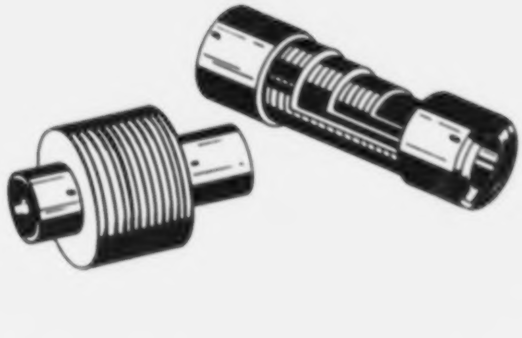


f. ______________________________ g. ______________________________

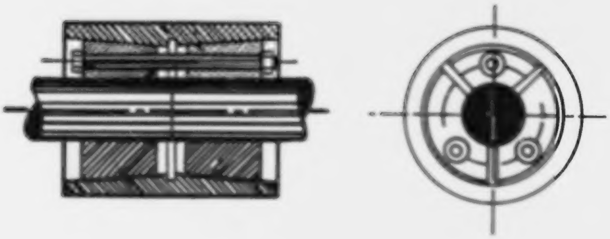


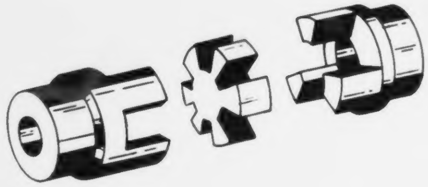
h. ______________________________



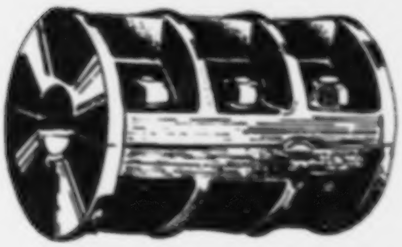


i. ______________________________ j. ______________________________

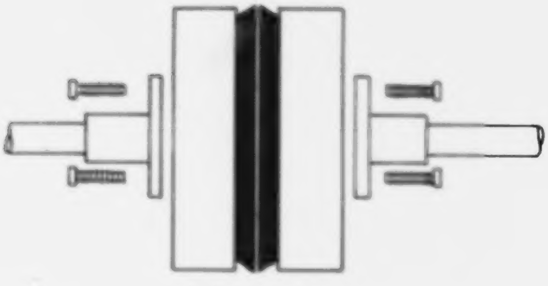




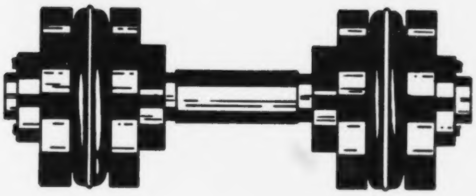
k. ______________________ l. ______________________



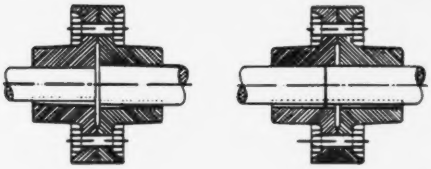
m. ______________________



n. ______________________

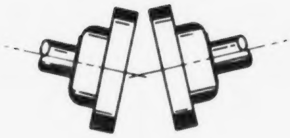


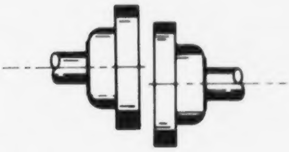
o. ______________________________

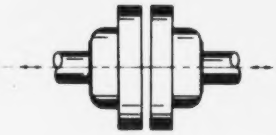


p. ______________________________

4. Distinguish between true alignment and misalignment. Place an "X" in the blank under the drawing illustrating true alignment.







a. ________________ b. ________________ c. ________________

5. Select from the following list methods used to align couplings. Place an "X" in the blanks before the correct methods.

______a. Calipers

______b. Folding rule and protractor

______c. Straightedge and feeler gage

______d. Straightedge and micrometers

______e. Leveling instrument and rod

______f. Dial indicator

6. Identify the formula used to determine angular alignment of couplings. Place an "X" in the blank before the correct formula.

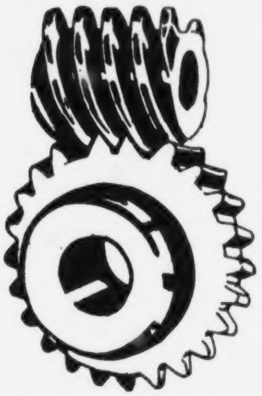
______a. $\frac{N \times T \times W \times L}{12}$

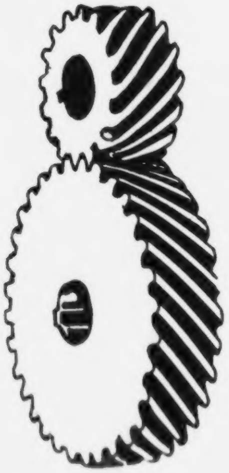
______b. $\frac{\text{Width in feet} \times \text{length in feet} \times \text{thickness in feet}}{27}$

______c. Front foot
A x C = X
X ÷ E = Amount for front foot

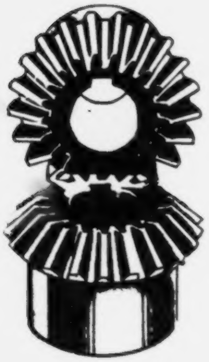
Back foot
A x D = Z
Z ÷ E = Amount for back foot

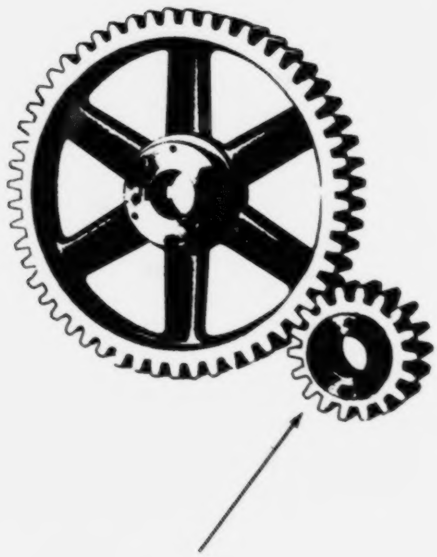
7. Identify the following types of gears. Write the correct names in the blanks provided.





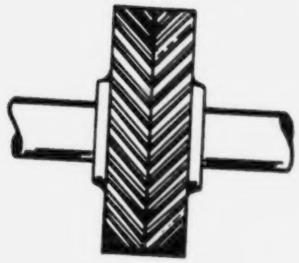
a. ______________________________ b. ______________________________

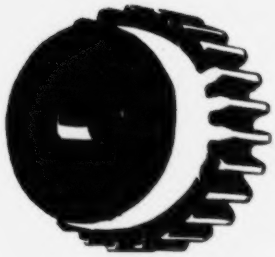




c. ______________________

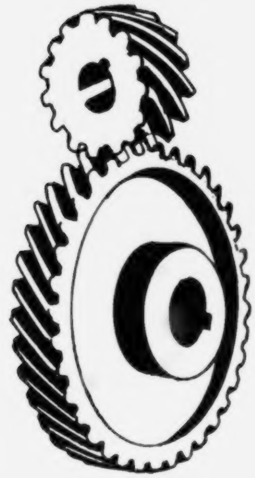
d. ______________________



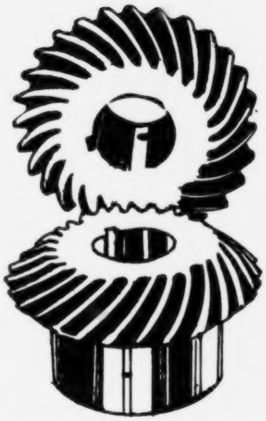


e. ______________________

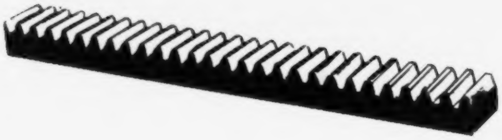
f. ______________________



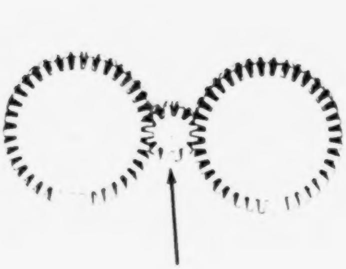
g. ______________________________



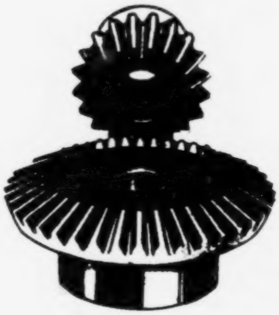
h. ______________________________



i. ______________________________

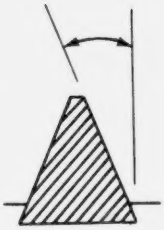


j. ______________________________

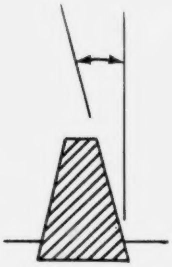


k. ______________________________

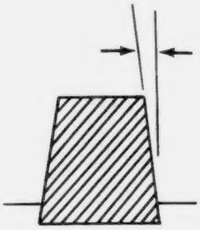
8. Select from the following drawings 20° and 14.5° pressure angles. Place an "O" in the blank under the 20° pressure angle and an "X" in the blank under the 14.5° pressure angle.



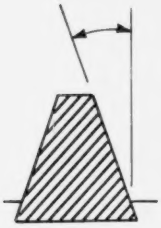
a. ____________



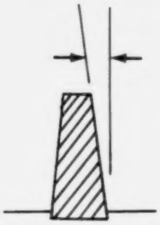
b. ____________



c. ____________



d. ____________



e. ____________

9. Select from the following list advantages of the 20° pressure angle. Place an "X" in the blanks before the correct statements.

_____a. Permits idlers to be used

_____b. Increases wear resistance

_____c. Permits pinions to be used with less teeth

_____d. Tends to clean gears

_____e. Increases rotary speed

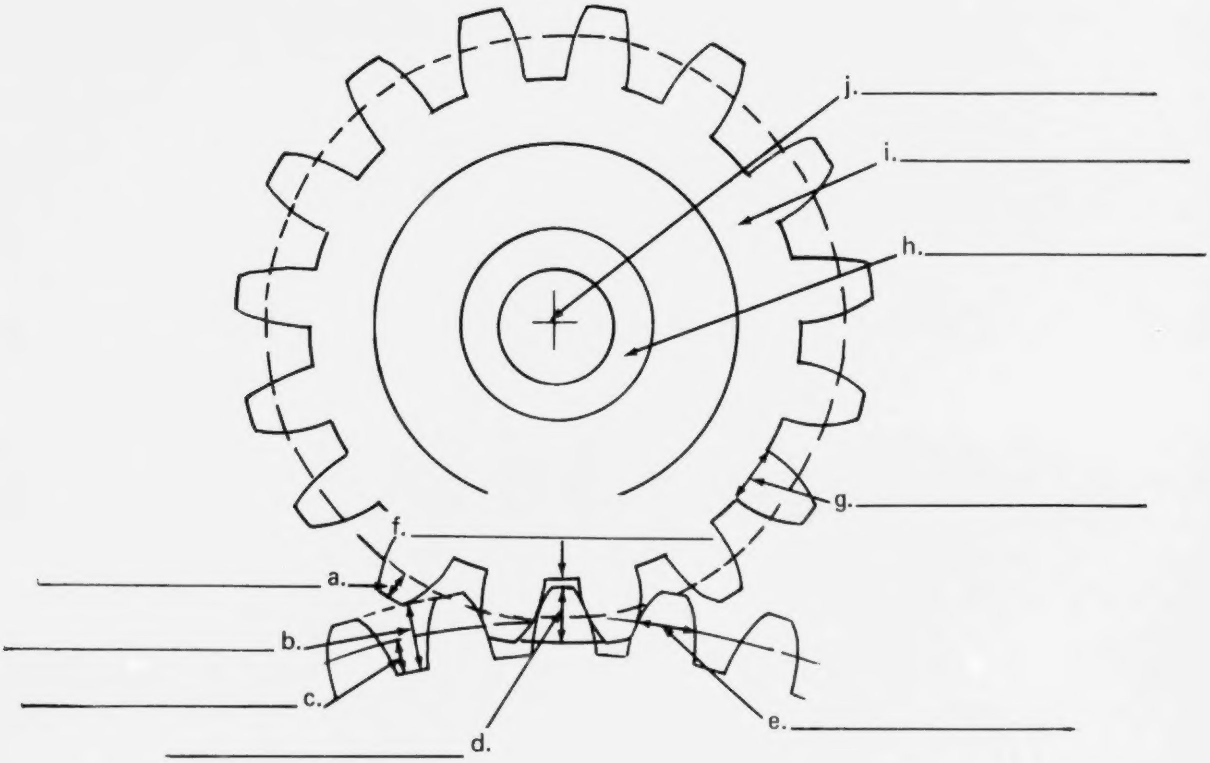
_____f. Increases strength

10. Distinguish between circular pitch and diametral pitch. Place a "C" in the blank before the statement describing circular pitch.

_____a. Distance from a point on one tooth to a corresponding point on the next tooth; measured along pitch line

_____b. Designates size and proportions of gear teeth specified by number of teeth in pi (π) (3.1416") along the pitch line of a gear

11. Identify parts of the gear illustrated below by writing correct names in the blanks provided.


j.
i.
h.
g.
f.
a.
b.
c.
d.
e.

12. Select from the following list reasons for backlash in gear drives. Place an "X" in the blanks before the correct statements.

______a. Provides running clearance

______b. Prevents heat generation

______c. Prevents frequent oil changes

______d. Prevents noise

______e. Prevents binding of mating gears

______f. Prevents belt wear

______g. Prevents gears from meshing together

______h. Prevents possible overload or failure of drive

______i. Prevents transmission of power

______j. Prevents abnormal wear

13. Name advantages of herringbone gears.

a. ______________________________

b. ______________________________

14. Describe a gear set and a gear train.

a. Gear set--______________________________

b. Gear train--______________________________

15. Distinguish between speed advantage and mechanical advantage. Place an "S" in the blank before the correct definition of speed advantage.

______a. Occurs when a small gear (pinion) is driven by a large gear; output shaft turns faster than input shaft

______b. Change in speed or force; occurs when large gear is driven by small gear

16. Describe gear ratio.

____

____

17. List major systems used for transmission of rotary motion between adjacent shafts.

a. ______________________________

b. ______________________________

c. ______________________________

18. List types of belts.

a. ______________________________

b. ______________________________

c. ______________________________

19. Describe multiple belt drive.

____

____

20. Distinguish between results of belt tension that is too tight or too loose. Place a "T" in the blanks before results of tension that is too tight and an "L" in the blanks before results tension that is too loose.

_____a. Unnecessary wear

_____b. Strained belts

_____c. Loss of power

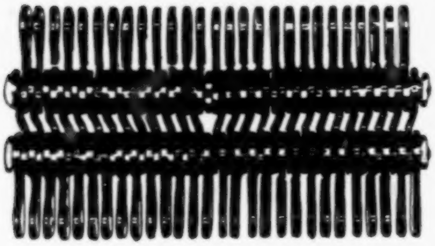
_____d. Slippage

_____e. Strained shafts

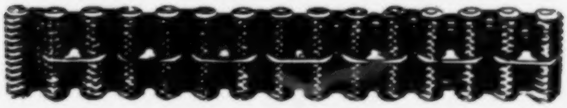
_____f. Excess vibration

_____g. Strained bearings

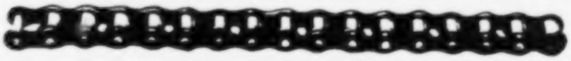
21. Identify types of chains used for power transmission in the following illustrations Write the correct names in the blanks provided.



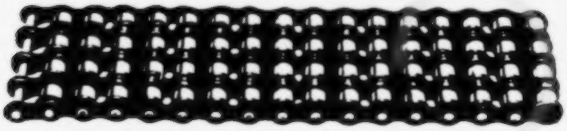
a. ______________________________



b. ______________________________

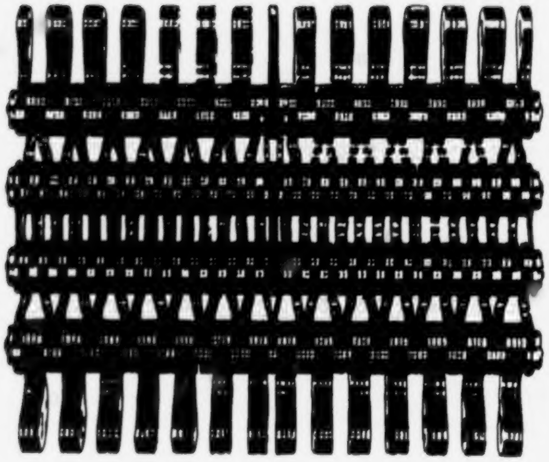


c. ______________________________

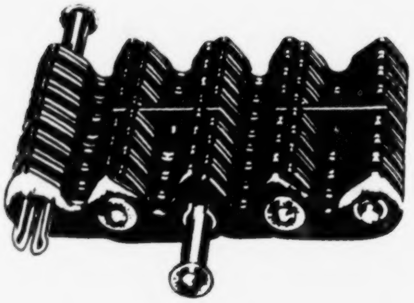


d. ______________________________

e. ______________________________

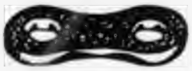


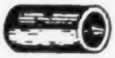
f. ____________________



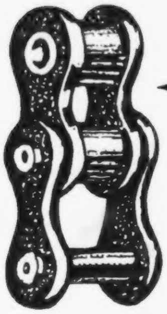
g. ____________________

22. Identify parts of a roller chain from the following illustrations. Write correct names in blanks provided.



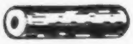


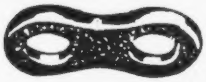
a. ____________________ b. ____________________

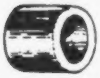


c. ______________________

d. ______________________







e. ______________ f. ______________ g. ______________

23. Complete the following chart on various center distances to obtain proper sag. Write the correct information in the blanks provided.

Shaft Centers	Sag	Shaft Centers	Sag
a. ________	3/8"	60"	l. ________
b. ________	f. ________	i. ________	1 1/2"
c. ________	5/8"	80"	m. ________
36"	g. ________	j. ________	n. ________
d. ________	7/8"	100"	o. ________
48"	h. ________	k. ________	2 1/2"
e. ________	1 1/8"		

24. Demonstrate the ability to:

    a. Align coupling using dial indicator.

    b. Use thickness gage and straightedge for vertical, angular, and horizontal alignment.

    c. Align pulley and/or sprocket.

    (NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

COUPLINGS, GEARS, AND DRIVES
UNIT VI

ANSWERS TO TEST

1. a. 4
   b. 11
   c. 9
   d. 2
   e. 8
   f. 6
   g. 12
   h. 7
   i. 5
   j. 1
   k. 10
   l. 3
   m. 13
   n. 14
   o. 16
   p. 15
   q. 17
   r. 18
   s. 19
2. a. R
   b. F
3. a. Gear
   b. Chain
   c. U-joint
   d. Air-flex
   e. Slider
   f. Dowel-drive
   g. Steel grid
   h. Coupling with tapered bushing
   i. Rubber-flex
   j. Bellows
   k. Compression
   l. Lug-drive
   m. Clamp or ribbed

n. Spacer

o. Floating

p. Flange

4. c

5. c, f

6. c

7. a. Worm

b. Helical

c. Miter

d. Pinion

e. Herringbone

f. Spur

g. Typical spiral

h. Miter with spiral teeth

i. Straight line

j. Idler

k. Bevel

8. b. X

d. O

9. b, c, f

10. a

11. a. Addendum

b. Dedendum

c. Whole depth

d. Working depth

e. Tooth thickness

f. Clearance

g. Root circle

h. Hub

i. Rim

j. Bore

12. a, b, d, e, h, j

13. a. Transmit power between parallel shafts

    b. Overcome high end-thrust present in helical gears

14. a. Two gears that mesh together

    b. Three or more engaged gears

15. a

16. Proportion of size of one gear in relation to size of another gear

17. a. Belts

    b. Chains

    c. Gears

18. a. V-belt

    b. Positive drive or gear belt

    c. Flat belt

19. Several belts used together to transmit power

20. a. L

    b. T

    c. L

    d. L

    e. T

    f. L

    g. T

21. a. Three-pitch silent

    b. Silent with middle guard

    c. Single-strand roller

    d. Multiple-strand roller

- e. Side flange silent
- f. Five-pitch silent
- g. Silent or inverted-tooth

22.
- a. Pin link plate
- b. Bushing
- c. Pin link
- d. Roller link
- e. Pin
- f. Roller link plate
- g. Roller

23.
- a. 18"
- b. 24"
- c. 30"
- d. 42"
- e. 54"
- f. 1/2"
- g. 3/4"
- h. 1"
- i. 70"
- j. 90"
- k. 125"
- l. 1 1/4"
- m. 1 5/8"
- n. 1 7/8"
- o. 2"

24. Performance skills evaluated to the satisfaction of the instructor

BEARINGS, PACKINGS, AND SEALS
UNIT VII

UNIT OBJECTIVE

After completion of this unit, the student should be able to identify types of bearings, packings and seals, and be able to install bearings using various methods. This knowledge will be evidenced by completion of job sheets and unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with bearings, packings, and seals to the correct definitions.
2. Identify major types of bearings.
3. Select from a list classifications of bearings.
4. Match bearing styles to the correct functions.
5. List types of bearing materials.
6. Select from a list qualities that influence selection of materials.
7. List reasons for bearing failure.
8. Identify parts of an antifriction ball bearing.
9. Match series of basic types of ball bearings to the correct number designations.
10. Arrange in order the procedure for mounting antifriction bearings.
11. Distinguish between correct and incorrect methods of removing a bearing from a shaft.
12. Identify common transmission units.
13. List types of sealing devices.
14. Identify types of non-contact seals.
15. List types of single contact seals.
16. Select from a list types of molded packing seals.

17. Select from a list types of materials used for compression packing.
18. Identify mechanical seals.
19. Select from a list factors that affect seal choice.
20. Identify uses of lockwashers and locknuts.
21. Demonstrate the ability to:
    a. Install antifriction bearing with an arbor press.
    b. Install bearing using hot oil, dry oven, or electric heater method.
    c. Install bearing using a piece of pipe.

BEARINGS, PACKINGS, AND SEALS
UNIT VII

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide student with objective sheet.

   B. Provide student with information and job sheets.

   C. Make transparencies.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Demonstrate and discuss procedures outlined in job sheets.

   G. Give test.

II. Instructional materials:

   A. Objective sheet

   B. Information sheet

   C. Transparency masters

      1. TM 1--Types of Bearings

      2. TM 2--Types of Bearings (Continued)

      3. TM 3--Non-Contact Seals

      4. TM 4--Single Contact Seals

      5. TM 5--Molded Packing Seals

      6. TM 6--Mechanical Seals

   D. Job sheets

      1. Job Sheet #1--Install Antifriction Bearing With an Arbor Press

      2. Job Sheet #2--Install Bearing Using Hot Oil, Dry Oven or Electric Heater Method

      3. Job Sheet #3--Install Bearing Using a Piece of Pipe

   E. Test

   F. Answers to test

III. Unit references:

A. *Maintenance Millwright I: Training Module.* Houston, Texas: Brown and Root, Inc.

B. Nelson, Carl A. *Millwrights' and Mechanics' Guide.* 2nd ed. Indianapolis, Indiana: Howard W. Sams and Co., Inc., 1978.

C. *Link-Belt Products and Components for Materials Handling and Power Transmission.* Catalog 1050. 4th ed. Indianapolis, Indiana: Link-Belt Company, 1965.

BEARINGS, PACKINGS AND SEALS
UNIT VII

INFORMATION SHEET

I. Terms and definitions

A. Bearing--That part of a machine in which another part turns or slides

B. Plain bearing--Operates on the principle of sliding motion

C. Antifriction bearing--Designed to overcome frictional resistance

D. Journal--That part of a shaft, axle, or spindle which turns in a bearing

E. Axis--Straight, imaginary line passing through a shaft on which the shaft revolves or should revolve

F. Friction--Resistance to motion between two surfaces that are in contact

G. Transmission unit--Assembly that contains and supports an anti-friction bearing; used to support shafts that transmit mechanical power

H. Flash point--Temperature at which oil may ignite

I. Radially--Developing uniformly around a central axis

J. Parallel--Extending in the same direction; equal distance apart and never meeting

K. Reciprocating--To move forward and backward alternately

L. Misalignment--Improper positioning of equipment

M. Arbor press--Type of equipment used to press-fit bearings, gears, cogs, and other equipment

N. Keyway--Groove cut into a shaft to accept a key

O. Splines--Ribbed or teeth-like portions of gears, seals, pulleys, impellers, and other equipment

P. Mics--Abbreviation for micrometers

Q. Labyrinth seal--Extremely complex in structure or arrangement

R. Tolerance--Allowable deviation from a standard

S. Temperature stick--Pencil-shaped object used to check temperature of heated metal

T. Sweat-fit--Heating process used to expand metal

INFORMATION SHEET

II. Major types of bearings (Transparencies 1and 2)

   A. Ball

      (NOTE: Types of ball bearings include radial, angular contact, self-aligning, and duplex.)

   B. Straight roller

   C. Taper roller

   D. Spherical roller (barrel roller)

   E. Concave roller

   F. Ball-thrust

   G. Needle roller

   H. Sleeve

   I. Typical journal roller

III. Classifications of bearings

   A. Plain

   B. Antifriction

IV. Functions of bearing styles

   A. Radial--Supports loads that act radially and/or at right angles to shaft center

   B. Thrust--Supports or resists endwise loads that act axially or parallel to the center line toward the shaft ends

   C. Guide--Supports and aligns members having sliding or reciprocating motion

V. Types of bearing materials

   A. Cast iron

   B. Bronze

   C. Babbitt

INFORMATION SHEET

D. Plastic

E. Rubber

F. Carbon

G. Aluminum bronze alloy

VI. Qualities that influence selection of materials

A. Ability to withstand sliding contact without excessive friction

B. Strength to withstand loads without deforming

C. Ability to permit grit or dirt, which may contaminate the lubricant, to become embedded

D. Ability to deform to permit distribution of load over the full bearing surface

E. Ability to conduct heat so frictional heat will dissipate and hot spots which may cause seizure will not develop

F. Ability to resist corrosion

VII. Reasons for bearing failure

A. Inferior material

B. Incorrect grooving

C. Unsuitable surface finish

D. Incorrect clearance

E. Faulty relining

F. Improper operating conditions

G. Excessive operating temperature

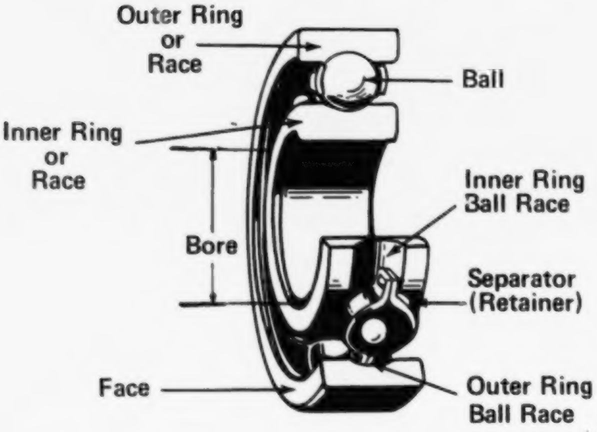
H. Foreign materials in oil supply

I. Inferior lubricants

J. Misalignment

INFORMATION SHEET

VIII. Parts of an antifriction ball bearing


Outer Ring or Race
Ball
Inner Ring or Race
Inner Ring Ball Race
Bore
Separator (Retainer)
Face
Outer Ring Ball Race

IX. Series and number designations of basic types of ball bearings

- A. Extra light--100
- B. Light--200
- C. Medium--300
- D. Heavy--400

(NOTE: Names applied to each series are descriptive of the relative proportions and load-carrying capacities.)

X. Procedure for mounting antifriction bearings

(NOTE: Preferred mounting method is to use an arbor press as this is the best way to control alignment, support, and force.)

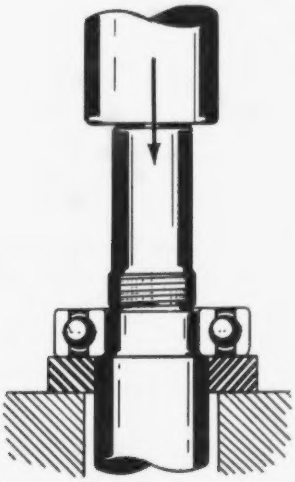
- A. Clean shaft and bearing housing
- B. Use compressed air to dry parts
- C. Clean dirt from keyways, splines, and grooves
- D. Remove burrs and slivers
- E. Clean and oil bearing seats
- F. Mic shaft
- G. Mic bearing bore
- H. Install bearing

INFORMATION SHEET

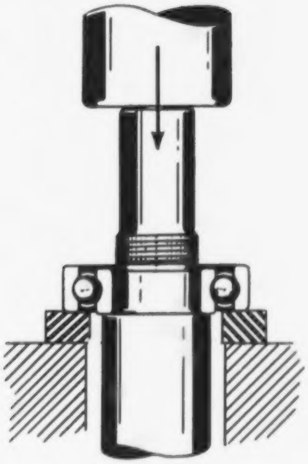
XI. Correct and incorrect methods of removing a bearing from a shaft

(CAUTION: Care must be exercised so that supporting blocks are under the inner rings so the force does not damage the rolling elements.)

A. Correct block spacing



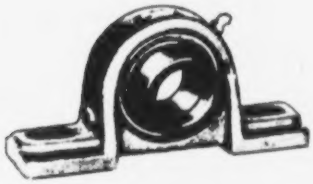
B. Incorrect block spacing



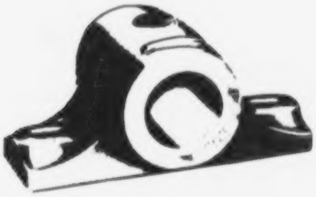
INFORMATION SHEET

XII. Common transmission units

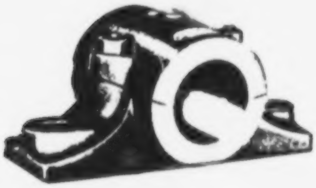
A. Typical pillow block



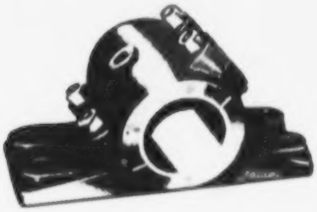
B. Solid pillow block



C. Split pillow block

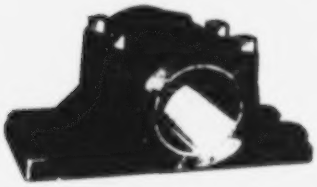


D. Angle pillow block

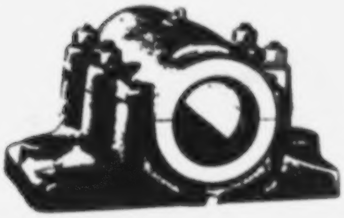


INFORMATION SHEET

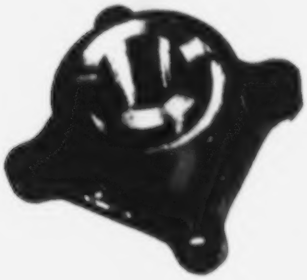
E. Gibbed pillow block



F. Ring-oiling pillow block



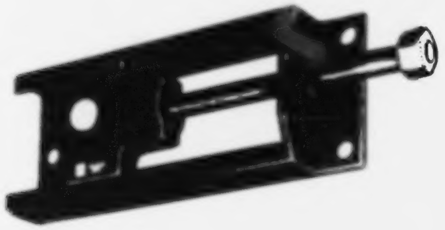
G. Flanged bearing unit



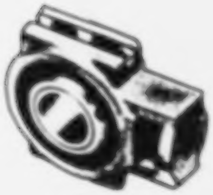
H. Flex-block flanged unit

INFORMATION SHEET

I. Take-up bearing assembly



J. Flex-block take-up unit



XIII. Types of sealing devices

A. Simple contact seals

B. Non-contact seals

C. Single contact seals

D. Molded packing seals

E. Compression packing

F. Split-oil seal

XIV. Types of non-contact seals (Transparency 3)

A. Plain

B. Annular groove (grease groove)

C. Labyrinth

XV. Types of single contact seals (Transparency 4)

A. Felt encased

B. Laminated felt

INFORMATION SHEET

    C. Unit type leather
    D. Unit type synthetic rubber
    E. Piston ring

XVI. Molded packing seals (Transparency 5)

    A. O-ring
    B. V-shape
    C. U-shape
    D. Rubber cup

XVII. Types of materials used for compression packing

    A. Asbestos
    B. Cotton
    C. Graphite
    D. Teflon
    E. Soft metals

XVIII. Mechanical seals (Transparency 6)

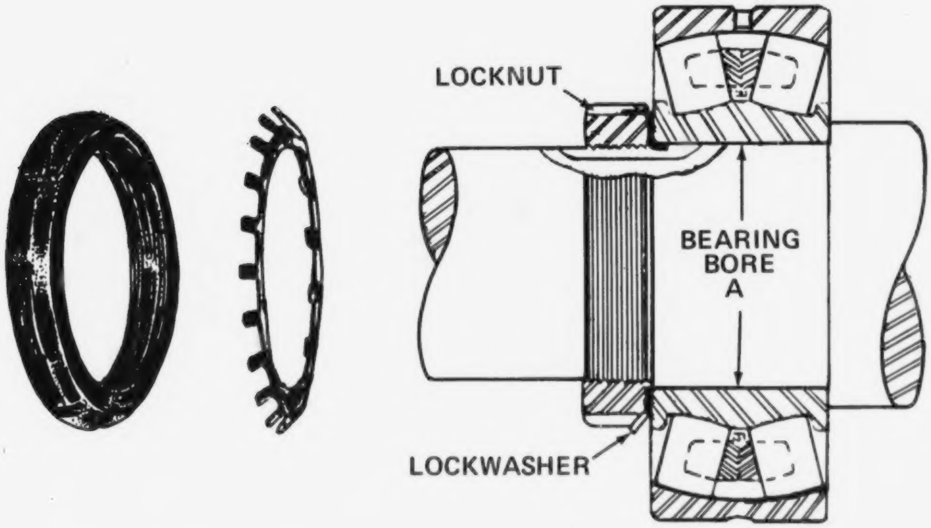
    A. Stuffing box
    B. Lantern ring (seal cage)
    C. Spring-loaded

XIX. Factors that affect seal choice

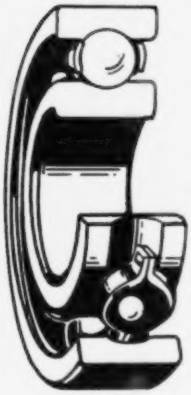
    A. Rotating or reciprocating motion
    B. Speed
    C. Temperature
    D. Amount of pressure or vacuum
    E. Type of fluid being sealed
    F. Amount of leakage or contamination allowed
    G. Accuracy and rigidity of the surfaces

INFORMATION SHEET

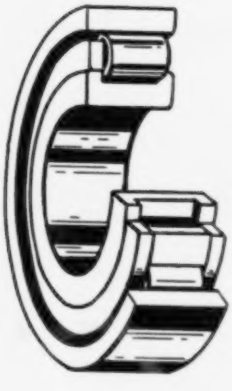
XX. Lockwashers and locknuts--Used to hold particular bearings in place


LOCKNUT
BEARING BORE A
LOCKWASHER

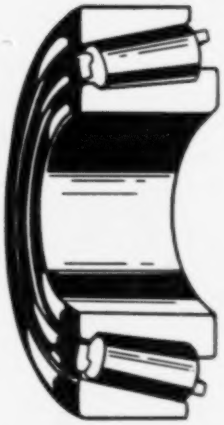
Types of Bearings



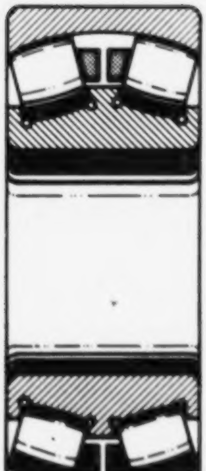
Ball



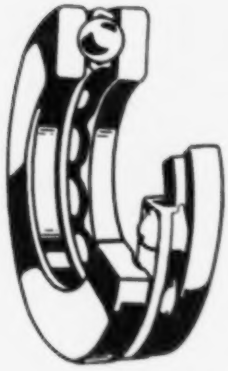
Straight-Roller



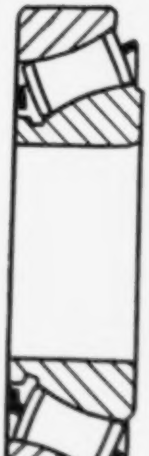
Taper Roller



Spherical Roller
(Barrel Roller)

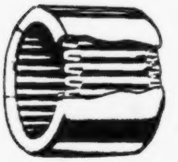


Ball-Thrust

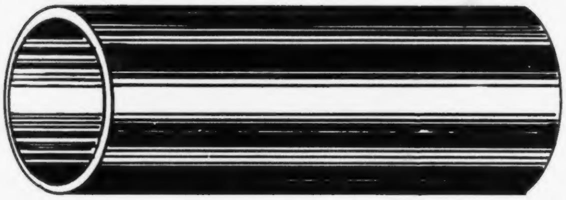


Concave Roller

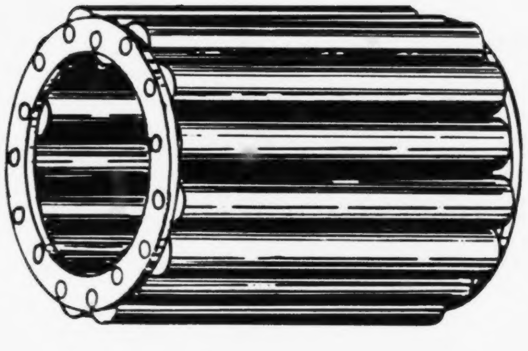
Bearings



Needle Roller

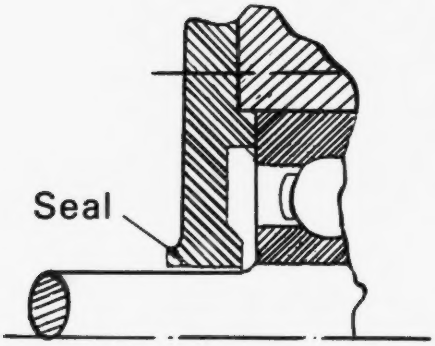


Sleeve

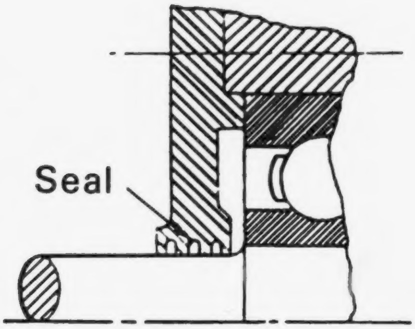


Typical Journal Roller

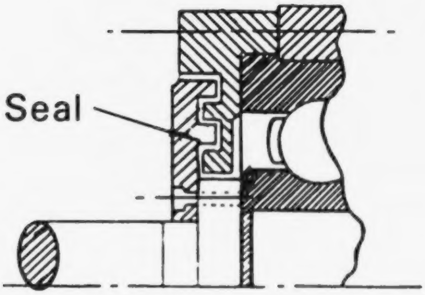
Non-Contact Seals



Plain

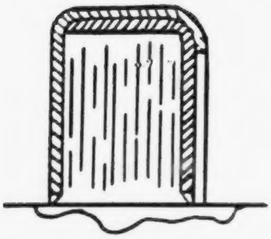


Annular Groove
(Grease Groove)

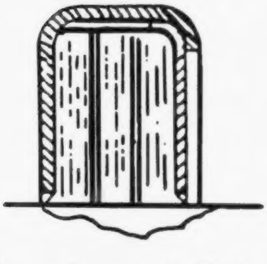


Labyrinth

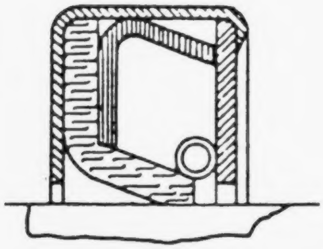
Single Contact Seals



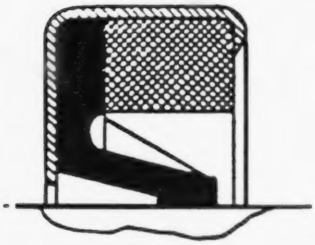
Felt Encased



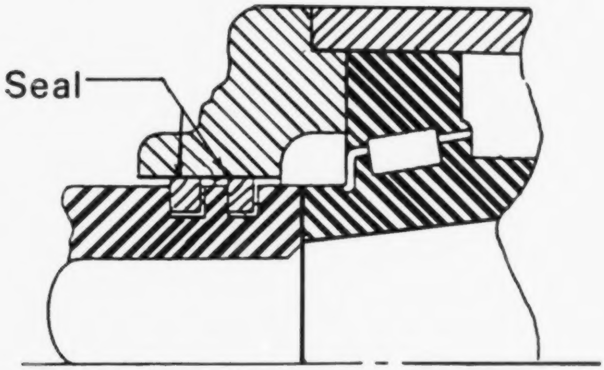
Laminated Felt



Unit Type Leather

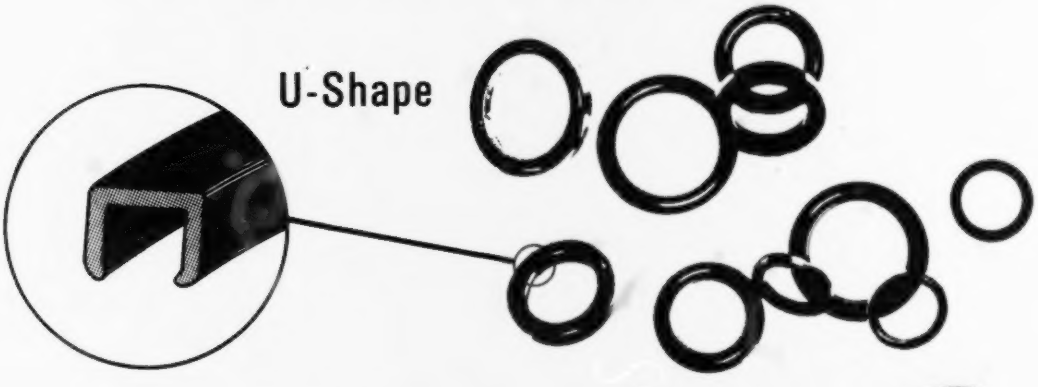


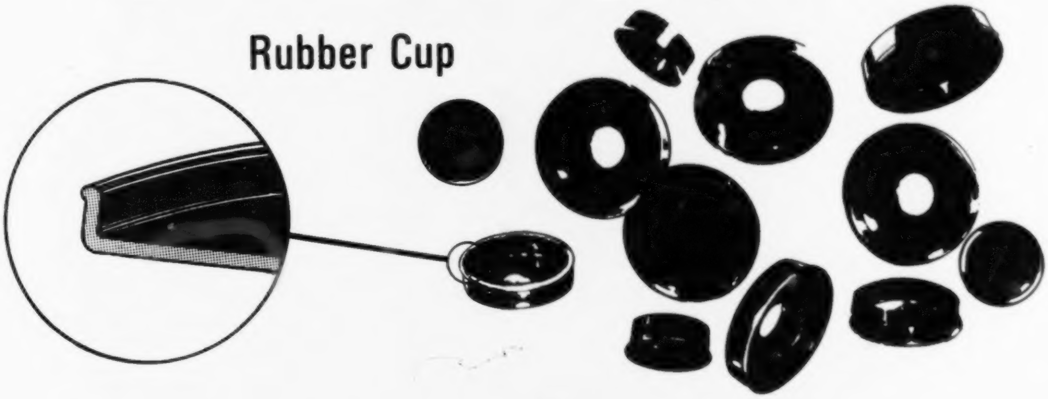
Unit Type Synthetic Rubber

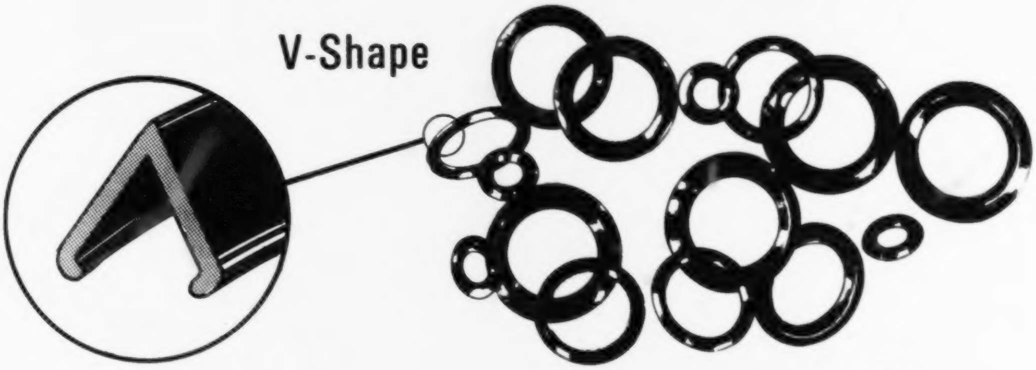


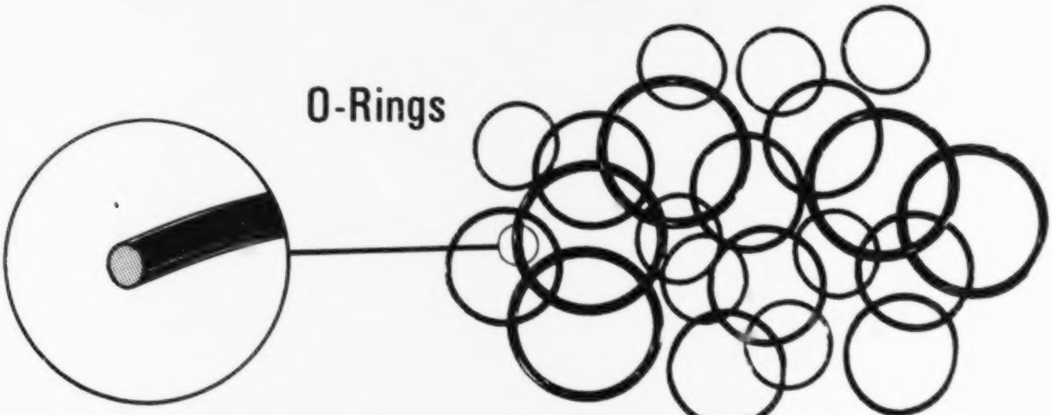
Piston Ring

Molded Packing Seals

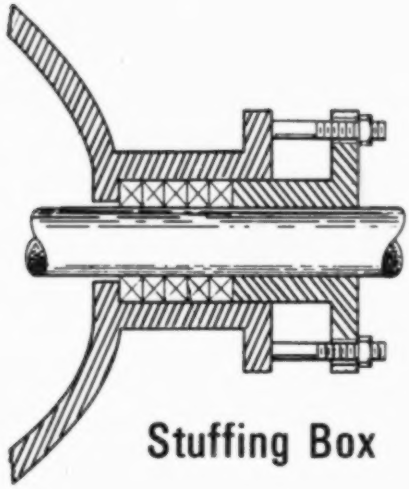




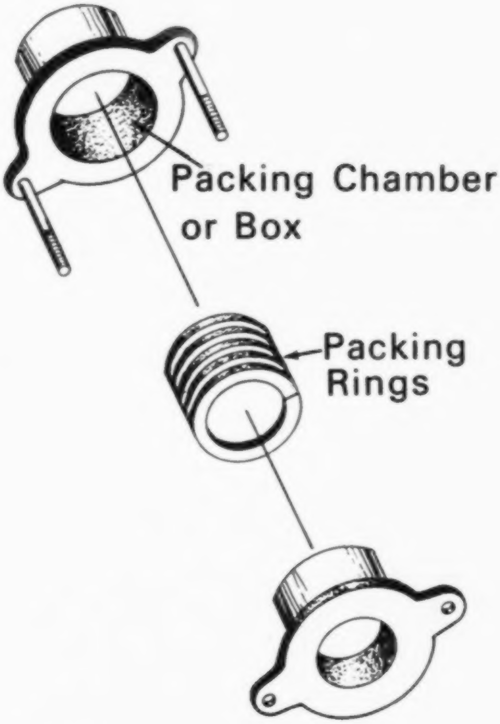




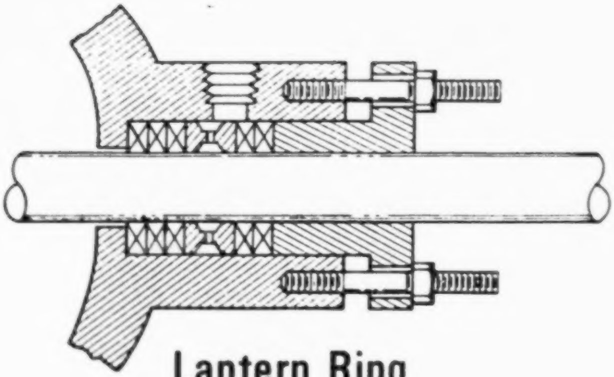
Types of Mechanical Seals



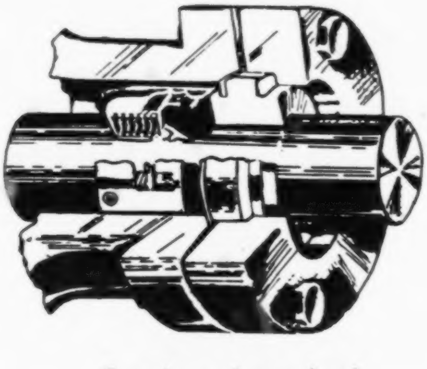
Stuffing Box


Packing Chamber
or Box
Packing
Rings

Basic Components of Stuffing Box



Lantern Ring
(Seal Cage)



Spring Loaded

BEARINGS, PACKINGS, AND SEALS
UNIT VII

JOB SHEET #1--INSTALL ANTIFRICTION BEARING WITH AN ARBOR PRESS

I. Tools and equipment

- A. Bearing and shaft
- B. Arbor press
- C. Oil
- D. Cleaning solvent
- E. Air compressor
- F. Small brush and/or rags

II. Procedure

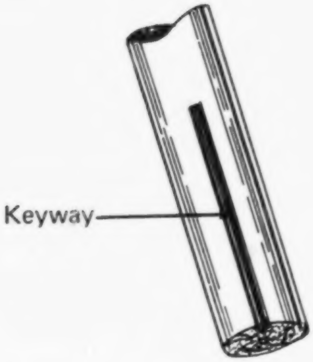
A. Clean shaft and bearing housing

(NOTE: Cleaning solvent may be used followed by compressed air to dry bearings.)

(CAUTION: Do not let bearings spin as this may cause damage.)

B. Clean dirt out of keyway, splines, and grooves (Figure 1)

FIGURE 1



C. Remove burrs and slivers

D. Clean and oil bearing seats

JOB SHEET #1

E. Mic shaft and record size

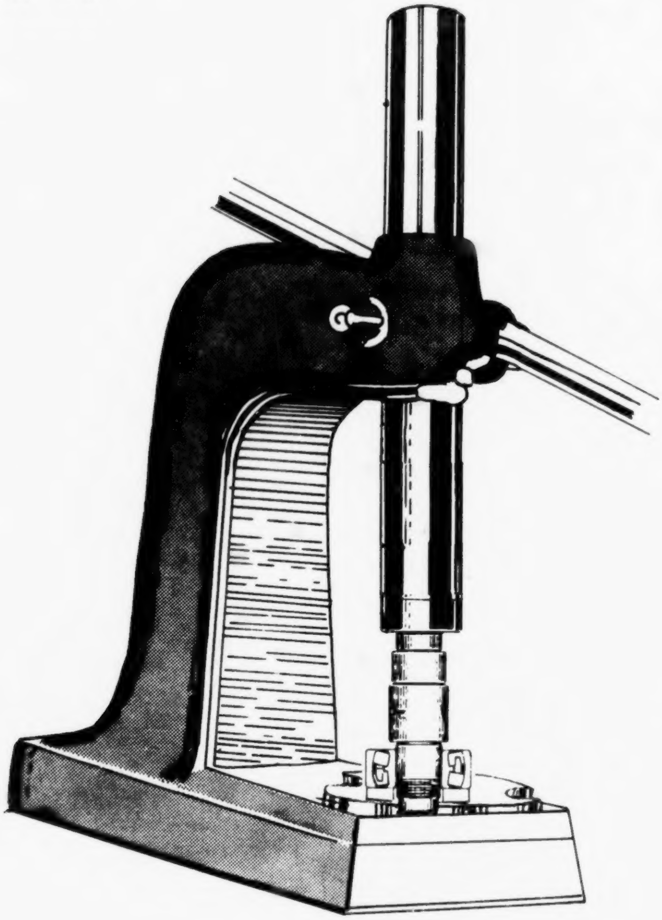
F. Mic bearing bore to determine if bearing is a slip-on fit or if it needs heating for installation

(NOTE: Common procedure for proper fit is 0.001" undersize to each one inch (1") of shaft diameter.)

G. Press bearing on straight and square (Figure 2)

(CAUTION: Press only on the inner ring.)

FIGURE 2



H. Press bearings until they are seated against the shaft or housing shoulder

BEARINGS, PACKINGS, AND SEALS
UNIT VII

JOB SHEET #2--INSTALL BEARING USING HOT OIL, DRY OVEN, OR ELECTRIC HEATER METHOD

I. Tools and equipment

A. Bearing and shaft

B. Hot oil tank, dry oven, or electric heater

C. Thermometer

D. Temperature stick

E. Cleaning solvent

F. Air compressor

G. Small brush and/or rags

H. Oil

II. Procedure

A. Clean shaft and bearing housing, using brush and cleaning solvent

B. Use compressed air to dry parts

(CAUTION: Do not let bearings spin as this may cause damage.)

C. Clean dirt out of keyway, splines, and grooves

D. Remove burrs and slivers

E. Clean and oil bearing seats

F. Mic shaft and record size

G. Mic bearing bore to determine if bearing is a slip-fit or if it needs heating for installation

(NOTE: Common procedure for proper fit is 0.001" undersize to each one inch (1") of shaft diameter.)

H. Heat bearing to a temperature of 150-400°F, depending on size of bearing and tolerance of sweat fit

(NOTE: Heating expands bearing so that it should slip over shaft with very little resistance.)

(CAUTION: Do not overheat bearing as this will effect its hardness. Caution should also be taken as to the flash point of oil being used.)

JOB SHEET #2

I. Use temperature stick to check temperature of bearing

J. Install bearing immediately after removing it from heat

K. Slip bearing along shaft until it is seated against shaft or housing shoulder

(CAUTION: Do not assume that bearing will fit and be sure it is straight and square.)

BEARINGS, PACKINGS, AND SEALS
UNIT VII

JOB SHEET #3--INSTALL BEARING USING A PIECE OF PIPE

I. Tools and equipment

  A. Bearing and shaft

  B. Short piece of pipe

  (NOTE: Pipe must be same diameter of inner ring of bearing.)

  C. Hammer

  D. Oil

  E. Cleaning solvent

  F. Air compressor

  G. Small brush and/or rags

II. Procedure

  A. Clean shaft and bearing housing, using brush and cleaning solvent

  B. Use compressed air to dry parts

  (CAUTION: Do not let bearings spin as this may cause damage.)

  C. Clean dirt out of keyway, splines and grooves

  D. Remove burrs and slivers

  E. Clean and oil bearing seats

  F. Mic shaft and record size

  G. Mic bearing bore to determine if bearing will fit without heating

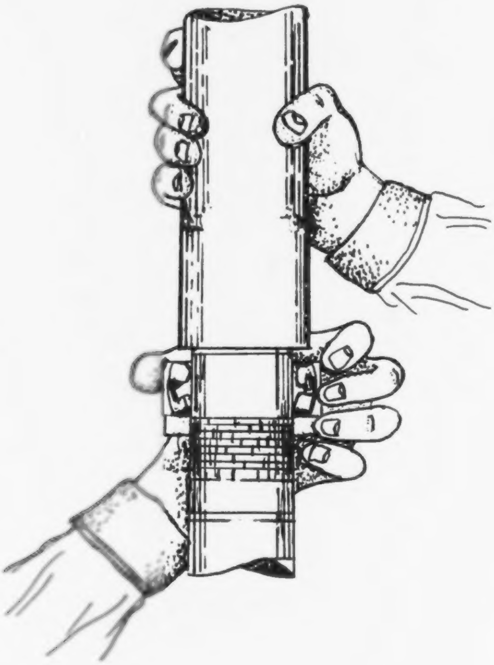
  (NOTE: Common procedure for proper fit is 0.001" to each one inch (1") of shaft diameter.)

  H. Start bearing on shaft

JOB SHEET #3

I. Slip piece of pipe over shaft with one hand and while holding bearing with other hand use a hammer-like motion to tap bearing onto shaft and into proper place (Figure 1)

FIGURE 1



BEARINGS, PACKINGS, AND SEALS
UNIT VII

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with bearings, packings, and seals to the correct definitions. Place the correct numbers in the blanks provided.

______a. That part of a machine in which another part turns or slides

______b. Operates on the principle of sliding motion

______c. Designed to overcome frictional resistance

______d. That part of a shaft, axle, or spindle which turns in a bearing

______e. Striaght, imaginary line passing through a shaft on which the shaft revolves or should revolve

______f. Resistance to motion between two surfaces that are in contact

______g. Assembly that contains and supports an antifriction bearing; used to support shafts that transmit mechanical power

______h. Temperature at which oil may ignite

______i. Developing uniformly around a central axis

______j. Extending in the same direction; equal distance apart and never meeting

______k. To move forward and backward alternately

______l. Improper positioning of equipment

______m. Type of equipment used to press-fit bearings, gears, cogs, and other equipment

______n. Groove cut into shaft to accept a key

______o. Ribbed or teeth-like portions of gears, seals, pulleys, impellers, and other equipment

1. Antifriction bearing
2. Friction
3. Flash point
4. Bearing
5. Transmission unit
6. Axis
7. Plain bearing
8. Journal
9. Keyway
10. Reciprocating
11. Arbor press
12. Radially
13. Misalignment
14. Parallel
15. Splines

______p. Abbreviation for micrometers

______q. Extremely complex in structure or arrangement

______r. Allowable deviation from a standard

______s. Pencil-shaped object used to check temperature of heated metal

______t. Heating process used to expand metal

16. Temperature stick

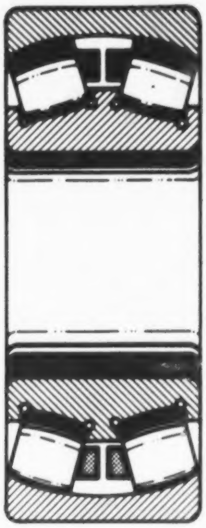
17. Tolerance

18. Labyrinth seal

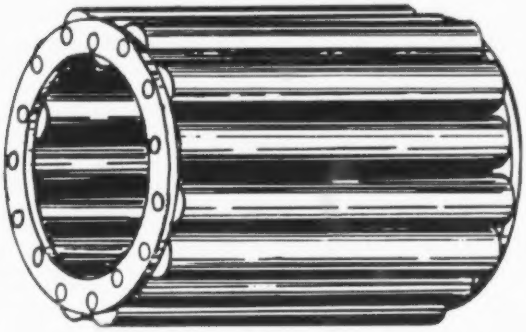
19. Sweat-fit

20. Mics

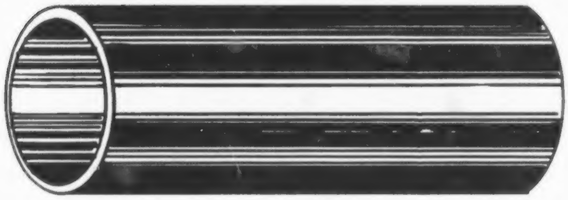
2. Identify the major types of bearings in the following illustrations. Write the correct names in the blanks provided.



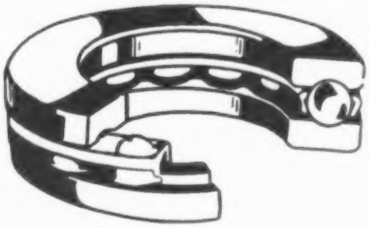
a. ______________________________



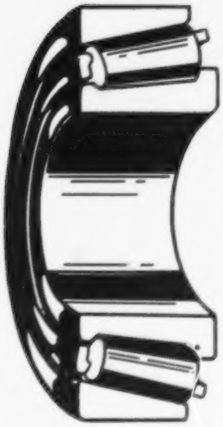
b. ______________________________



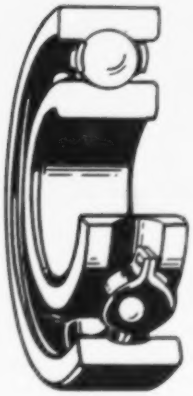
c. ______________________________



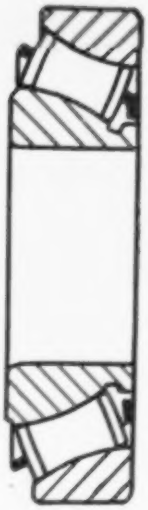
d. ______________________________



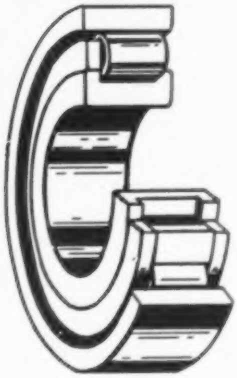
e. ____________________



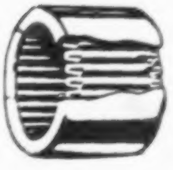
f. ____________________



g. ____________________



h. ____



i. ____

3. Select from the following list classifications of bearings. Place an "X" in the correct blanks.

_____a. Friction

_____b. Axial

_____c. Antifriction

_____d. Plain

4. Match bearing styles to the correct functions. Place the correct numbers in the blanks provided.

______a. Supports loads that act radially and/or at right angles to the shaft center	1. Guide
______b. Supports or resists endwise loads that act axially or parallel to the centerline toward the shaft ends	2. Radial
______c. Supports and aligns members having sliding or reciprocating motion	3. Thrust

5. List types of bearing materials.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

6. Select from the following list qualities that influence selection of materials. Place an "X" in the correct blanks.

______a. Ability to create hot spots

______b. Ability to deform under stress

______c. Resistance to corrosion

______d. Strength to withstand loads without deforming

______e. Ability to contaminate lubricant

______f. Ability to deform to permit distribution of load over the full bearing surface

______g. Ability to withstand sliding contact without excessive friction

______h. Ability to permit grit or dirt, which may contaminate the lubricant, to become embedded

______i. Resistance to misalignment

______j. Ability to conduct heat so frictional heat will dissipate and hot spots which may cause seisure will not develop

7. List reasons for bearing failure.

a. ______________________

b. ______________________

c. ______________________

d. ______________________

e. ______________________

f. ______________________

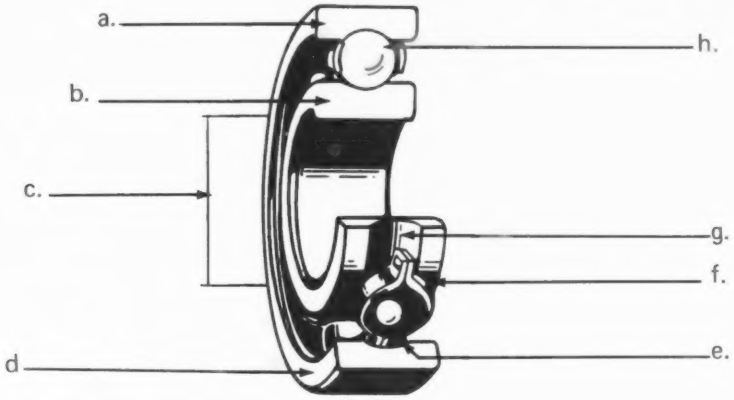
g. ______________________

h. ______________________

i. ______________________

j. ______________________

8. Identify parts of the anti-friction ball bearing illustrated below. Place the correct names in the blanks provided.



a. ______________

b. ______________

c. ______________

d. ______________

e. ______________

f. ______________

g. ______________

h. ______________

9. Match series of basic types of ball bearings to the correct number designations. Place the correct numbers in the blanks provided.

______a. 100	1. Heavy
______b. 200	2. Extra light
______c. 300	3. Medium
______d. 400	4. Light

10. Arrange in order the procedure for mounting antifriction bearings. Place a "1" in front of the first step, a "2" in front of the second, and so on.

______a. Mic shaft

______b. Clean and oil bearing seats

______c. Use compressed air to dry parts

______d. Install bearing

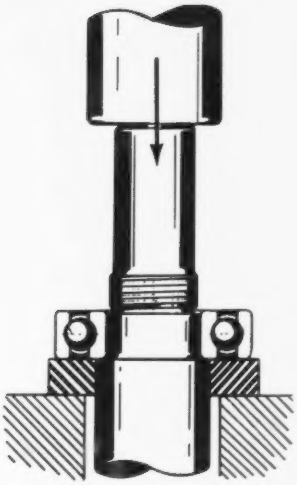
______e. Mic bearing bore

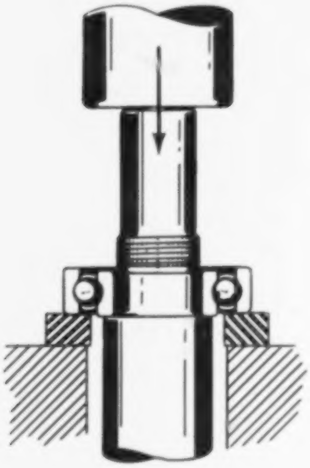
______f. Clean shaft and bearing housing

______g. Clean dirt from keyways, splines, and grooves

______h. Remove burrs and slivers

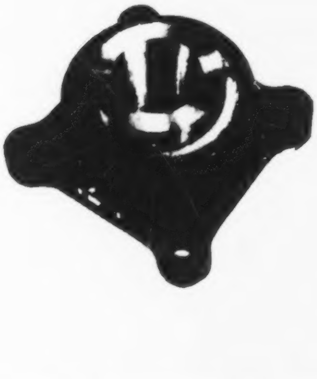
11. Distinguish between correct and incorrect methods of removing a bearing from a shaft. Place a "C" for the correct method and an "I" for the incorrect method in the blanks provided.

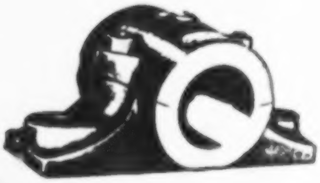




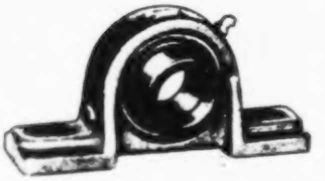
a. ________ b. ________

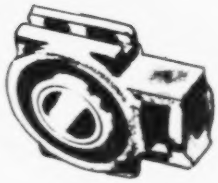
12. Identify common transmission units in the following illustrations. Write the correct names in the blanks provided.





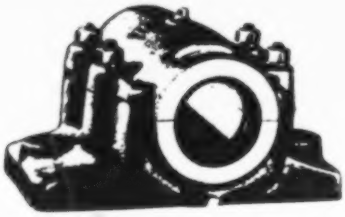
a. ________________________ b. ________________________

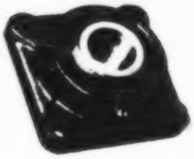




c. ______________________

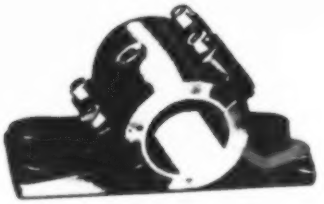
d. ______________________

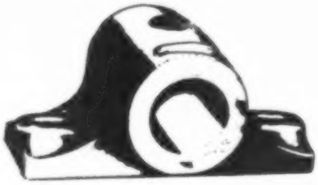




e. ______________________

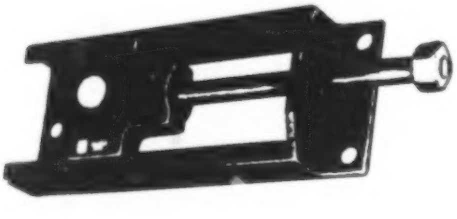
f. ______________________

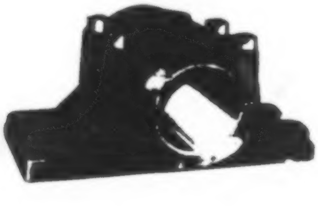




g. ______________________

h. ______________________





i. ______________________

j. ______________________

13. List types of sealing devices.

    a. ______________________________

    b. ______________________________

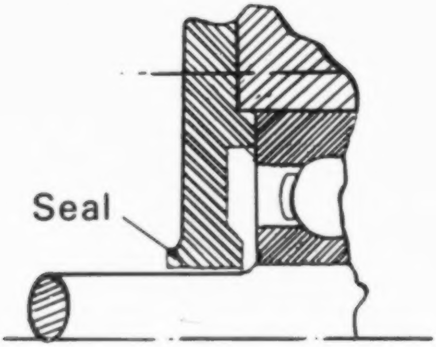
    c. ______________________________

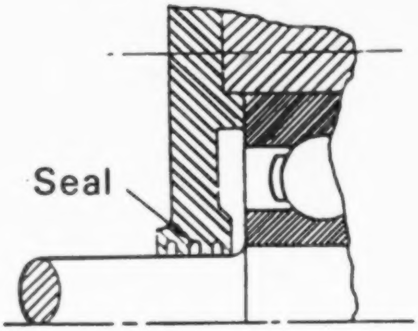
    d. ______________________________

    e. ______________________________

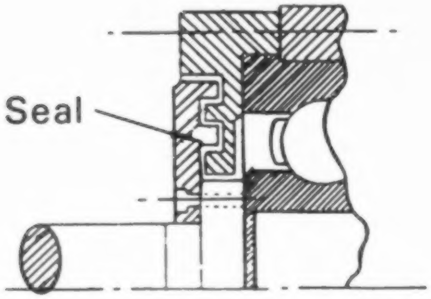
    f. ______________________________

14. Identify the following types of non-contact seals. Place the correct names in the blanks provided.





a. ______________________ b. ______________________



c. ______________________

15. List types of single contact seals.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

16. Select from the following list types of molded packing seals. Place an "O" in the correct blanks.

_______ a. U-Ring

_______ b. V-shape

_______ c. Plastic cup

_______ d. O-ring

_______ e. Worm-ring

_______ f. Rubber cup

_______ g. T-shape

_______ h. U-shape

17. Select from the following list types of material used for compression packing. Place an "X" in the correct blanks.

_______ a. Teflon

_______ b. Aluminum

_______ c. Stainless steel

_______ d. Cotton

_______ e. Grease

_______ f. Graphite

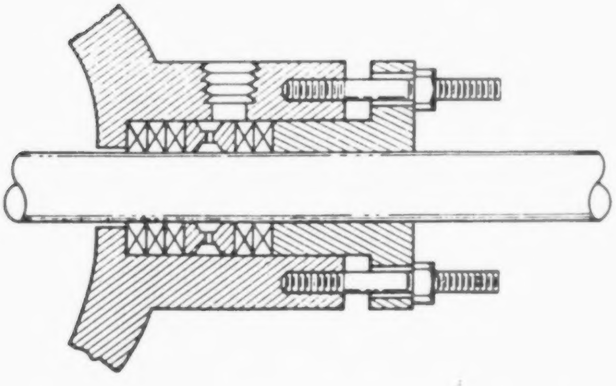
_______ g. Soft metals

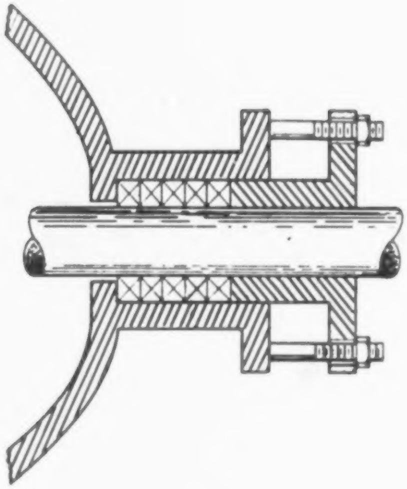
_______ h. Wood

_______ i. Carbite

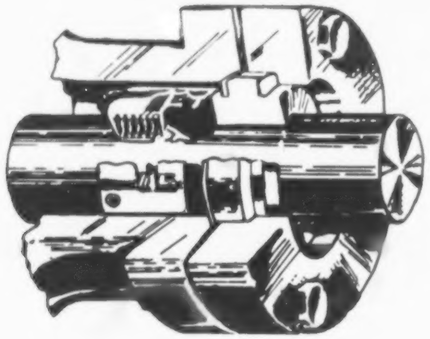
_______ j. Asbestos

18. Identity the mechanical seals in the following illustrations. Place the correct names in the blanks provided.





a. ______________________ b. ______________________



c. ______________________

19. Select from the following list factors that affect seal choice. Place an "X" in the correct blanks.

_____a. Type of fluid being sealed

_____b. Amount of pressure or vacuum

_____c. Amount of vibration

_____d. Type of bearings used

_____e. Amount of leakage or contamination allowed _____f. Rotating or reciprocating motion

_____g. Size of shaft

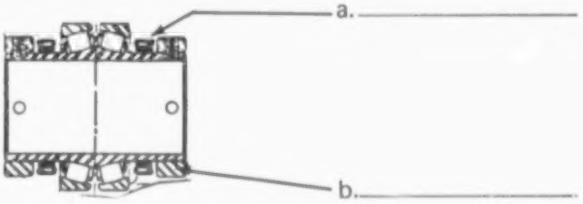
_____h. Temperature

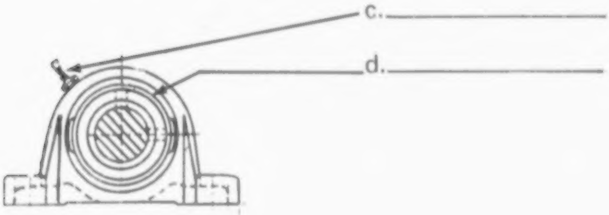
_____i. Accuracy and rigidity of the surfaces

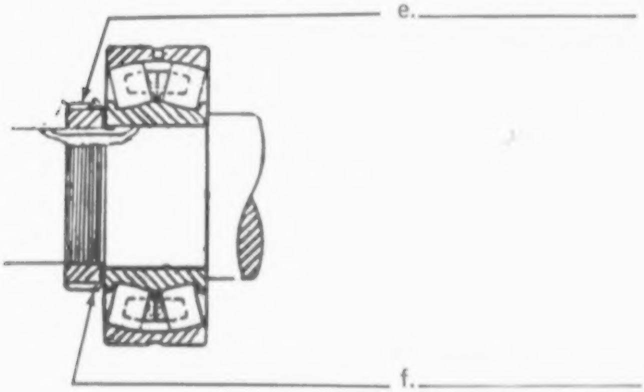
_____j. Accuracy of alignment

_____k. Speed

20. Identify the correct use of locknuts and lockwashers in the following illustrations. Place an "X" in the correct blanks.







21. Demonstrate the ability to:

    a. Install antifriction bearing with an arbor press.

    b. Install bearing using hot oil, dry oven, or electric heater method.

    c. Install bearing using a piece of pipe.

(NOTE: If the above activities have not been accomplished prior to the test, ask the instructor when they should be completed.)

BEARINGS, PACKINGS, AND SEALS
UNIT VII

ANSWERS TO TEST

1. a. 4
   b. 7
   c. 1
   d. 8
   e. 6
   f. 2
   g. 5
   h. 3
   i. 12
   j. 14
   k. 10
   l. 13
   m. 11
   n. 9
   o. 15
   p. 20
   q. 18
   r. 17
   s. 16
   t. 19

2. a. Spherical roller (barrel roller)
   b. Typical journal roller
   c. Sleeve
   d. Ball-thrust
   e. Taper roller
   f. Ball
   g. Concave roller
   h. Straight roller
   i. Needle roller

3. c, d

4. a. 2
   b. 3
   c. 1

5. a. Cast iron
   b. Bronze
   c. Babbitt
   d. Plastic
   e. Rubber
   f. Carbon
   g. Aluminum bronze alloy
6. c, d, f, g, h, j
7. a. Inferior material
   b. Incorrect grooving
   c. Unsuitable surface finish
   d. Incorrect clearance
   e. Faulty relining
   f. Improper operating conditions
   g. Excessive operating temperature
   h. Foreign materials in oil supply
   i. Inferior lubricants
   j. Misalignment
8. a. Outer ring (race)
   b. Inner ring (race)
   c. Bore
   d. Face
   e. Outer ring ball race
   f. Separator
   g. Inner ring ball race
   h. Ball

9. a. 2
   b. 4
   c. 3
   d. 1
10. a. 6
    b. 5
    c. 2
    d. 8
    e. 7
    f. 1
    g. 3
    h. 4
11. a. C
    b. I
12. a. Flanged bearing unit
    b. Split pillow block
    c. Typical pillow block
    d. Flex-block take-up unit
    e. Ring-oiling pillow block
    f. Flex-block flanged unit
    g. Angle pillow block
    h. Solid pillow block
    i. Take-up bearing assembly
    j. Gibbed pillow block
13. a. Simple contact seals
    b. Non-contact seals
    c. Single contact seals
    d. Molded packing seals

- e. Compression packing
- f. Split oil seal

14. a. Labyrinth
    b. Plain
    c. Annular groove (grease groove)
15. a. Felt encased
    b. Laminated felt
    c. Unit type leather
    d. Unit type synthetic rubber
    e. Piston ring
16. b, d, f, h
17. a, d, f, g, j
18. a. Lantern ring (seal cage)
    b. Stuffing box
    c. Spring-loaded
19. a, b, e, f, h, i, k
20. e, f
21. Performance skills evaluated to the satisfaction of the instructor

MILLWRIGHT INSTRUCTIONAL MATERIALS
PROGRESS CHART

Section I-1

Equipment Layout, Anchoring, and Setup

	UNIT I PUMPS					UNIT II COMPRESSORS					UNIT III STEAM TURBINES					UNIT IV CONVEYORS and SUPPORT STRUCTURES				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Job	Unit Test	Set, Align, and Level a Vertical Pump	Set, Align, and Level a Horizontal Pump			Unit Test	Set, Align, and Level a Compressor				Unit Test					Unit Test	Install Conveyor and Components Using Basic Steps.			
Student's Name																				
1																				
2																				
3																				
4																				
5																				
6																				
7																				

Accuracy	85% Correct	To Satisfaction of Instructor	To Satisfaction of Instructor			85% Correct	To Satisfaction of Instructor				85% Correct					85% Correct	To Satisfaction of Instructor			
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16																				
17																				
18																				
19																				
20																				

MILLWRIGHT INSTRUCTIONAL MATERIALS
PROGRESS CHART

Section I-1

Equipment Layout, Anchoring, and Setup

	UNIT I PUMPS					UNIT II COMPRESSORS					UNIT III STEAM TURBINES					UNIT IV CONVEYORS and SUPPORT STRUCTURES				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Job	Unit Test	Set, Align, and Level a Vertical Pump	Set, Align, and Level a Horizontal Pump			Unit Test	Set, Align, and Level a Compressor				Unit Test					Unit Test	Install Conveyor and Components Using Basic Steps.			
Student's Name																				
1																				
2																				
3																				
4																				
5																				
6																				
7																				

Accuracy	85% Correct	To Satisfaction of Instructor	To Satisfaction of Instructor			85% Correct	To Satisfaction of Instructor				85% Correct					85% Correct	To Satisfaction of Instructor			
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MILLWRIGHT INSTRUCTIONAL MATERIALS
PROGRESS CHART

Section I-2
Equipment Layout,
Anchoring, and Setup

	UNIT V GEAR BOXES and SPEED REDUCERS					UNIT VI COUPLINGS, GEARS, and DRIVES				UNIT VII BEARINGS, PACKINGS, and SEALS									
	1	2	3	4	5	1	2	3	4	1	2	3	4	5					
Job	Unit Test					Unit Test	Align Coupling Using Dial Indicator	Use Thickness Gage and Straight Edge for Vertical, Angular, and Horizontal Alignment	Align Pulley and/or Sprocket	Unit Test	Install Antifriction Bearing Using an Arbor Press	Install Bearing Using Hot-Oil, Dry Oven, or Electric Heater Method	Install Bearing Using a Piece of Pipe						
Student's Name																			
1																			
2																			
3																			
4																			
5																			
6																			
7																			

	Accuracy																		
	85% Correct					85% Correct	Within 1/1000 of an Inch	Within 1/1000 of an Inch	Exact Alignment	85% Correct	To Satisfaction of Instructor	To Satisfaction of Instructor	To Satisfaction of Instructor						
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MILLWRIGHT INSTRUCTIONAL MATERIALS
PROGRESS CHART

Section I-2
Equipment Layout, Anchoring, and Setup

Job	UNIT V GEAR BOXES and SPEED REDUCERS					UNIT VI COUPLINGS, GEARS, and DRIVES				UNIT VII BEARINGS, PACKINGS, and SEALS									
	1	2	3	4	5	1	2	3	4	1	2	3	4	5					
Student's Name	Unit Test					Unit Test	Align Coupling Using Dial Indicator	Use Thickness Gage and Straight Edge for Vertical, Angular, and Horizontal Alignment	Align Pulley and/or Sprocket	Unit Test	Install Antifriction Bearing Using an Arbor Press	Install Bearing Using Hot-Oil, Dry Oven, or Electric Heater Method	Install Bearing Using a Piece of Pipe						
1																			
2																			
3																			
4																			
5																			
6 337																			
7																			

388

		Accuracy																			
		85% Correct						85% Correct	Within 1/1000 of an Inch	Within 1/1000 of an Inch	Exact Alignment	85% Correct	To Satisfaction of Instructor	To Satisfaction of Instructor	To Satisfaction of Instructor						
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SAFETY PRECAUTIONS
UNIT I

UNIT OBJECTIVE

After completion of this unit, the student should be able to list safety precautions and tips for preventive maintenance. This knowledge will be evidenced by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with safety precautions to the correct definitions.
2. List safety precautions.
3. List safety tips for preventive maintenance on belts, chains, and drives.
4. List safety tips for preventive maintenance on bearings, couplings, and packing seals.

SAFETY PRECAUTIONS
UNIT I

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

   A. Provide students with objective sheet.

   B. Provide students with information sheet.

   C. Make transparency.

   D. Discuss unit and specific objectives.

   E. Discuss information sheet.

   F. Give test.

II. Instructional materials:

   A. Objective sheet

   B. Information sheet

   C. Transparency Master--TM 1--Safety Clothing

   D. Test

   E. Answers to test

SAFETY PRECAUTIONS
UNIT I

INFORMATION SHEET

I. Terms and definitions

A. Maintenance--Upkeep of equipment

B. Guards--Protective or safety devices that house parts of equipment such as belts, pulleys, sheaves, gears, and couplings

C. Emergency switches--Red buttons or bars used to stop machinery

D. Lock-out--Safety procedure whereby worker actually locks and tags equipment to prevent anyone from turning on equipment and causing injury or damage

E. Isolated--Set apart or disconnected

F. Non-sparking tools--Special tools made from materials such as brass, bronze, or aluminum

G. Flammable--Capable of being ignited easily and burning with extreme rapidity

H. OSHA (Occupational Safety and Health Act)--Created in 1970 within the Federal Department of Labor; establishes guidelines and rules that must be followed by employers to ensure safety and health of workers in all phases of industry

I. Bearing--Machine part in which another part, such as a shaft or journal, turns or slides

J. Stuffing box--Type of seal used to control leakage at the point a rod or shaft enters an enclosure that is at a pressure above or below that of the surrounding area

K. Seals--Devices used for controlling and preventing loss of lubricating fluids in vessels or assemblies

L. Packing--Form of seal usually associated with a condition where motion occurs

M. Sheave--Grooved wheel

N. Pulley--Wheel used to transmit power by means of a band, belt, or chain

O. Sprocket--A toothed wheel shaped to engage with a chain

P. Axial alignment--Proper positioning of two shafts in relationship to each other

INFORMATION SHEET

Q. Tube expander--Assembly used to make a hydraulic and mechanical seal between tube and tube sheet

R. Over-rolling--Process of over expanding a tube to the degree that it has been reduced in thickness enough to lose structural strength

S. Babbitt--Metal alloy used to line sleeve bearings, bearing shells, and end-of-line bearings

T. Bolt stretch--Process of tightening a bolt until a tensile stress causes elongation or stretch

U. Coupling--Device used to connect the ends of adjacent parts or objects

V. Etching--To produce an impression or corrosion from friction and/or acid

W. Journal--That part of a rotating shaft, axle, roll, or spindle that turns in a bearing

II. Safety precautions (Transparency 1)

A. Shut down all equipment before any maintenance work is done

B. Do not remove guards, but if necessary for maintenance they must be re-installed

C. Know where all emergency switches are located

D. Never wear gloves if it is necessary to work on operating equipment

E. Avoid working over operating equipment

F Be sure lock-out procedures are followed while servicing equipment

G. Be sure each craft uses its own lock-out tags and locks

H. Be sure the tag is removed only by the person who put it on

I. Isolate equipment with piping systems from the system before opening

J. Close suction, discharge, and auxiliary line valves before servicing

K. Use bleed valves to relieve pressure before draining equipment

L. Dispose of oily rags and waste properly and regularly

M. Never leave tools or supplies where they may be knocked off onto equipment or on another person

INFORMATION SHEET

N. Examine tools prior to use to be sure they are proper and safe

O. Use containers to hold tools and supplies when performing overhead work

P. Use only non-sparking tools when there is a danger of igniting flammable materials

Q. Use correct tools for the job and use them only for the purposes they were designed for

R. Wear safety clothing at all times

S. Know and comply with OSHA standards

T. Before initial start of conveyors be sure no one is near them and that all tools and equipment have been removed from them

III. Safety tips for preventive maintenance on belts, chains, and drives

A. Always follow manufacturer's and company recommendations for safe maintenance practices

B. Be sure all guards are adequate and properly installed

C. Check sheaves and pulleys for wear or damage

D. Check and replace worn or damaged belts

E. Check belt tension frequently

F. Check for misalignment of drives

G. Take precautions to keep pulleys in balance so there is no shaft vibration which would eventually lead to a bent or broken shaft

H. Examine chains and sprockets to be sure they are positioned parallel and are in true axial alignment

I. Inspect chains regularly and if necessary clean them; use a good solvent and then relubricate

(NOTE: Adequate lubrication is one of the most important factors for proper operation.)

J. Check sprockets when a chain is replaced as they probably are also worn enough to warrant changing

K. Drain and change lubricants in all drive casings according to manufacturer's recommendations

INFORMATION SHEET

L. Lubricate all pulleys, sheaves, and sprockets regularly

M. Follow manufacturer's recommendations for correct types of lubricants to use

IV. Safety tips for preventive maintenance on bearings, couplings, and seals

A. Inspect bearings, couplings, seals, packings, and stuffing boxes regularly and lubricate or replace as necessary

B. Look for excessively hardened areas (streaks or spots), cracks, and etchings when inspecting bearings

C. Be sure to check the journal and/or shaft for defects if a bad bearing is found

D. Take extra precautions before and during mounting rolling contact bearings as they can be damaged mechanically

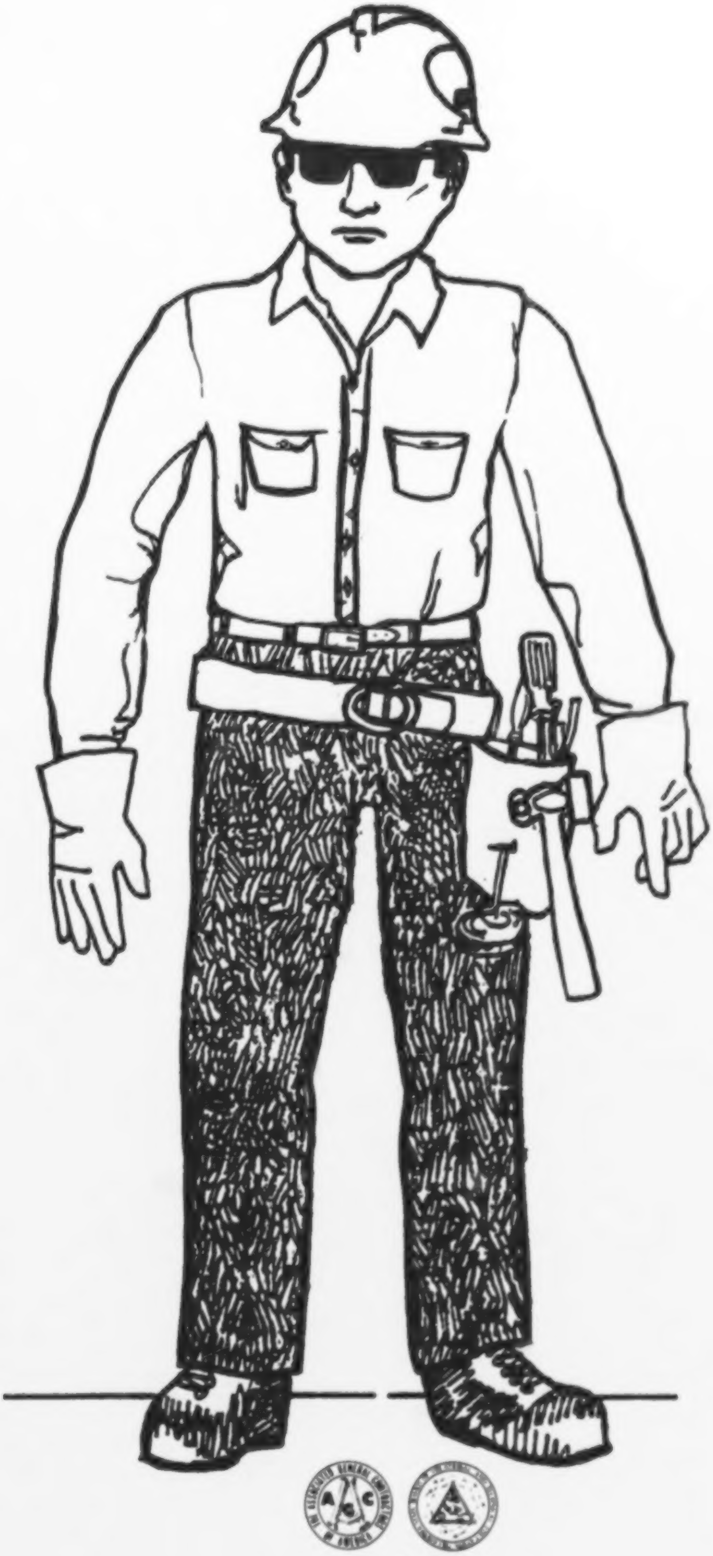
E. Take caution when selecting thrust bearings

(NOTE: They should suit the service for which they are intended.)

F. Check couplings periodically (every six months) for wear and lubrication

G. Check seals and packings periodically for leakage

Safety Clothing



TM 1

SAFETY PRECAUTIONS
UNIT I

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with safety precautions to the correct definitions. Place the correct numbers in the blanks provided.

______a. Upkeep of equipment

______b. Protective or safety devices that house parts of equipment, such as belts, pulleys, sheaves, gears, and couplings

______c. Red buttons or bars used to stop machinery

______d. Safety procedure whereby worker actually locks and tags equipment to prevent anyone from turning on equipment and causing injury or damage

______e. Set apart or disconnected

______f. Special tools made from materials such as brass, bronze, or aluminum

______g. Capable of being ignited easily and burning with extreme rapidity

______h. Created in 1970 within the Federal Department of Labor; establishes guidelines and rules that must be followed by employers to ensure safety and health of workers in all phases of industry

______i. Machine part in which another part, such as a shaft or journal, turns or slides

______j. Type of seal used to control leakage at the point a rod or shaft enters an enclosure that is at a pressure above or below that of the surrounding area

______k. Device used for controlling and preventing loss of lubricating fluids in vessels or assemblies

______l. Form of seal usually associated with a condition where motion occurs

1. OSHA (Occupational Safety and Health Act
2. Stuffing box
3. Non-sparking tools
4. Seals
5. Emergency switches
6. Maintenance
7. Packings
8. Isolated
9. Guards
10. Flammable
11. Lock-out
12. Bearing

_____m. Grooved wheel

_____n. Wheel used to transmit power by means of a band, belt, or chain

_____o. A toothed wheel shaped to engage with a chain

_____p. Proper positioning of two shafts in relationship to each other

_____q. Assembly used to make a hydraulic and mechanical seal between tube and tube sheet

_____r. Process of over-expanding a tube to the degree that it has been reduced in thickness enough to lose structural strength

_____s. Metal alloy used to line sleeve bearings, bearing shells, and end-of-line bearings

_____t. Process of tightening a bolt until a tensile stress causes elongation or stretch

_____u. Device used to connect the ends of adjacent parts or objects

_____v. To produce an impression or corrosion from friction and/or acid

_____w. That part of a rotating shaft, axle, roll, or spindle that turns in a bearing

13. Over-rolling
14. Coupling
15. Sheave
16. Axial alignment
17. Pulley
18. Bolt stretch
19. Sprocket
20. Etching
21. Babbitt
22. Tube expander
23. Journal

2. List twelve safety precautions.

a. ______________________________

b. ______________________________

c. ______________________________

d. ______________________________

e. ______________________________

f. ______________________________

g. ______________________________

h. ______________________________

i. ______________________________

j.

k.

l.

3. List ten safety tips for preventive maintenance on belts, chains, and drives.

a.

b.

c.

d.

e.

f.

g.

h.

i.

j.

4. List five safety tips for preventive maintenance on bearings, couplings, and seals.

a.

b.

c.

d.

e.

SAFETY PRECAUTIONS
UNIT I

ANSWERS TO TEST

1. a. 6
   b. 9
   c. 5
   d. 11
   e. 8
   f. 3
   g. 10
   h. 1
   i. 12
   j. 2
   k. 4
   l. 7
   m. 15
   n. 17
   o. 19
   p. 16
   q. 22
   r. 13
   s. 21
   t. 18
   u. 14
   v. 20
   w. 23

2. Any twelve of the following:
   a. Shut down equipment before any maintenance work is done
   b. Do not remove guards; but if necessary for maintenance they must be re-installed
   c. Know where all emergency switches are located
   d. Never wear gloves if it is necessary to work on operating equipment
   e. Avoid working over operating equipment
   f. Be sure lock-out procedures are followed while servicing equipment
   g. Be sure each craft uses its own lock-out tags and locks
   h. Be sure the tag is removed only by the person who put it on
   i. Isolate equipment with piping systems from the system before opening
   j. Close suction, discharge, and auxilary line valves before servicing
   k. Use bleed valves to relieve pressure before draining equipment
   l. Dispose of oily rags and waste properly and regularly

m. Never leave tools or supplies where they may be knocked off onto equipment or on another person

n. Examine tools prior to use to be sure they are proper and safe

o. Use containers to hold tools and supplies when performing overhead work

p. Use only non-sparking tools when there is danger of igniting flammable materials

q. Use correct tools for the job and use them only for the purposes they were designed for

r. Wear safety clothing of all times

s. Know and comply with OSHA standards

t. Before initial start of conveyors be sure no one is near them and that all tools and equipment have been removed from them

3. Any ten of the following:

a. Always follow manufacturer's and company recommendations for safe maintenance practices

b. Be sure all guards are adequate and properly installed

c. Check sheaves and pulleys for wear or damage

d. Check and replace worn or damaged belts

e. Check belt tension frequently

f. Check for misalignment of drive

g. Take precautions to keep pulleys in balance so there is no shaft vibration which would eventually had to a bent or broken shaft

h. Examine chains and sprockets to be sure they are positioned parallel and are in true axial alignment

i. Inspect chains regularly and if necessary clean them; use a good solvent and then relubricate

j. Check sprockets when a chain is replaced as they probably are also worn enough to warrant changing

k. Drain and change lubricant in all drive casings according to manufacturer's recommendations

l. Lubricate all pulleys, sheaves, and sprockets regularly

m. Follow manufacturer's recommendations for correct types of lubricants to use

4. Any five of the following:

   a. Inspect bearings, couplings, seals, packings, and stuffing boxes regularly and lubricate or replace as necessary

   b. Look for excessively hardened areas (streaks or spots), cracks, and etchings when inspecting bearings

   c. Be sure to check the journal and/or shaft for defects if a bad bearing is found

   d. Take extra precautions before and during mounting rolling contact bearings as they can be damaged mechanically

   e. Take caution when selecting thrust bearings

   f. Check couplings periodically (every six months) for wear and lubrication

   g. Check seals and packings periodically for leakage

MAINTENANCE
UNIT II

UNIT OBJECTIVE

After completion of this unit, the student should be able to list maintenance procedures pertaining to all equipment and perform maintenance on most types of equipment. This knowledge will be evidenced by completion of the unit test with a minimum of 85 percent accuracy.

SPECIFIC OBJECTIVES

After completion of this unit, the student should be able to:

1. Match terms associated with maintenance procedures to the correct definitions.
2. List maintenance procedures related to belts, chains, and drives.
3. List maintenance procedures related to bearings, couplings, gears, and seals.
4. Select from a list maintenance procedures related to conveyors.
5. Select from a list general maintenance procedures.

MAINTENANCE
UNIT II

SUGGESTED ACTIVITIES

I. Suggested activities for instructor:

  A. Provide students with objective sheet.

  B. Provide students with information sheet.

  C. Discuss unit and specific objectives.

  D. Discuss information sheet.

  E. Give test.

II. Instructional materials:

  A. Objective sheet

  B. Information sheet

  C. Test

  D. Answers to test

III. Unit reference--Nelson, Carl A. *Millwrights' and Mechanics' Guide.* 2nd ed. Indianapolis, Indiana: Howard W. Sams and Co., Inc., 1978.

MAINTENANCE
UNIT II

INFORMATION SHEET

I. Terms and definitions

   A. Maintenance--Upkeep of equipment to ensure trouble-free operation, quality of work performed, and increased life of equipment

   B. Drive--Means of giving motion to a machine or machine part, such as a motor

   C. Drive take-up--Adjustable device used to release tension on belts and chains so they can be replaced and adjusted

   D. Lubricate--To apply grease or oil to control friction and keep moving parts operating with a minimum of wear

   E. Belt dressing--Substance used to keep belts pliable to ensure a gripping effect and decrease slippage and creeping

   F. Sprocket--Toothed wheel shaped to engage with a chain

   G. Parallel--Extending in the same direction; equal distance apart and never meeting

   H. Axial alignment--Proper positioning of two shafts in relation to each other

   I. Solvent--Liquid cleaning fluid used to dissolve or eliminate unwanted materials

   J. Babbitt--Metal alloy used to line sleeve bearings, bearings, shells, and end-of-line bearings

   K. Stuffing box--Type of seal used to control leakage at the point a rod or shaft enters an enclosure that is at a pressure above or below that of the surrounding area

   L. Alignment--Proper positioning or adjustment of parts in relation to each other

II. Maintenance procedures related to belts, chains, and drives

   A. Follow manufacturer's recommendations

   B. Always use matched sets from one manufacturer when replacing belts on multiple V-belt drives

   C. Always replace all belts on any one drive when replacement of a belt is necessary

INFORMATION SHEET

D. Never pry or roll belts on drive; always use drive take-up

E. Lubricate take-up rails when necessary

F. When installing leather belts always put the flesh side (rough side) on outside

G. Clean belts and apply belt dressing whenever necessary

(CAUTION: Be very careful not to use an inferior belt dressing; deal only with reputable manufacturers.)

H. When replacing a chain be sure to check sprockets as they probably are worn enough to need changing also

I. Examine chains and sprockets to be sure they are positioned parallel and are in true axial alignment

J. Inspect chains regularly and clean if necessary, using a good solvent, then relubricate

K. Drain and change lubricants in all drive casings according to manufacturer's recommendations

(NOTE: Follow manufacturer's recommendations for types of lubricants to use.)

L. Inspect steam turbines equipped with oil rings once during each shift

M. Check gear boxes equipped with sight level indicators at least once a day

III. Maintenance procedures related to bearings, couplings, gears, and seals

A. Inspect bearings, couplings, seals, packings, and stuffing boxes regularly and lubricate and/or replace as necessary

B. Replace bearings if they have streaks, spots, cracks, or etchings

C. Fit babbitt lined sleeve bearings and bearing shells, scraping very lightly so as not to remove too much metal at a time; check and fit occassionally until the correct clearance is obtained

D. Check couplings periodically (every six months) for wear and lubrication

E. Check hub separation when aligning or installing couplings on a shaft

(NOTE: This is one of the limiting factors which prevent a motor shaft from wearing against the end of the motor bearings.)

INFORMATION SHEET

F. Always maintain full engagement of gears on couplings having external gear teeth on hubs and internal gear teeth in the covers

G. Take extreme caution to obtain correct alignment when using rigid couplings

H. Check seals and packings periodically for leakage

I. Keep all surfaces clean and always use clean fluids when installing packings and seals

J. Exercise care when replacing damaged seals and seal parts in the order that has been determined by study of the equipment and not necessarily by the way they were removed

K. Never tighten lip-type packings excessively when installing as this may crush the lip and damage the packing

L. Consult packing manufacturers for specific clearance allowances when installing cup packings

M. When repacking stuffing boxes, be sure to remove all old packing, thoroughly clean box, and check all parts and piping to be sure they are not clogged before replacing new packing

N. Watch installation and break-in of seals carefully

O. Never replace seals with old seals; when a seal is removed always replace with a new one

P. Take extreme care when inspecting mechanical seals not to damage or distort the optically flat surfaces; clean all seal parts, especially the inside bores, before inspection

IV. Maintenance procedures related to conveyors

A. Lubricate squeaky or sluggish rollers when necessary

B. Regrease bearings with fittings about twice a year, depending on use

C. Follow manufacturer's instructions when servicing motor gearcase and reducers

D. Maintain proper oil level in all gear cases and reducers

E. Clean and lubricate all conveyer bearings every five years or 10,000 hours according to manufacturer's recommendations

F. Check and maintain proper tension on conveyor belts

G. Maintain proper belt tracking

(NOTE: Primary belt control is made with snub rollers or first return roller.)

(CAUTION: On long belt conveyors or where conveyor is subjected to extreme atmospheric conditions, be sure to allow for shrinkage.)

H. Clean and service return rollers when necessary

(NOTE: Quite frequently the return rollers accumulate foreign materials and will force the belt out of line.)

I. Clean and service in-floor conveyor track frequently

V. General maintenance procedures

A. Check and replace all filters where and when needed according to manufacturer's recommendations

B. Check all tolerances, clearances, and gaging according to manufacturer's recommendations

C. Do not over-lubricate as this will cause an increase in temperature which could cause equipment failure

D. Check and replace hoses when necessary

E. Check and replace brushes when necessary

F. Check and run auxillary and emergency equipment periodically to be sure it will function when needed

G. Check hydraulic systems occasionally and be able to identify and correct malfunctions

H. Check operating pressures of equipment and if necessary, adjust to manufacturer's specifications

MAINTENANCE
UNIT II

TEST

NAME ______________________________ SCORE ______________

1. Match terms associated with maintenance to the correct definitions. Place the correct numbers in the blanks provided.

_____a. Upkeep of equipment to ensure trouble-free operation, quality of work performed, and increased life of equipment

_____b. Means of giving motion to a machine or machine part, such as a motor

_____c. Adjustable device used to release tension on belts and chains so they can be replaced and adjusted

_____d. To apply grease or oil to control friction and keep moving parts operating with a minimum of wear

_____e. Substance used to keep belts pliable to ensure a gripping effect and decrease bolt slippage and creeping

_____f. Toothed wheel shaped to engage with a chain

_____g. Extending in the same direction; equal distance apart and never meeting

_____h. Proper positioning of two shafts in relation to each other

_____i. Liquid cleaning fluid used to dissolve or eliminate unwanted materials

_____j. Metal alloy used to line sleeve bearings, bearings, shells, and end-of-line bearings

_____k. Type of seal used to control leakage at the point a rod or shaft enters an enclosure that is at a pressure above or below that of the surrounding area

_____l. Proper positioning or adjustment of parts in relation to each other

1. Axial Alignment
2. Alignment
3. Sprocket
4. Babbitt
5. Drive
6. Stuffing box
7. Drive take-up
8. Maintenance
9. Belt dressing
10. Lubricate
11. Parallel
12. Solvent

2. List eight maintenance procedures related to belts, chains, and drives.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

   e. ____________________

   f. ____________________

   g. ____________________

   h. ____________________

3. List eight maintenance procedures related to bearings, couplings, gears, and seals.

   a. ____________________

   b. ____________________

   c. ____________________

   d. ____________________

   e. ____________________

f. ____

____

g. ____

____

h. ____

____

4. Select from the following list maintenance procedures related to conveyors. Place a "C" in the blanks before the correct statements.

_____a. Maintain proper oil level in all gear cases and reducers

_____b. Maintain proper belt tracking

_____c. Scrub and polish in-floor conveyor track frequently

_____d. Lubricate squeaky or sluggish belts when necessary

_____e. Clean and service turn rollers when necessary

_____f. Clean and lubricate all conveyor bearings every 10 years or 25,000 hours

_____g. Always pull belts up tight, especially long belts

_____h. Regrease bearings with fittings about twice a year, depending on use

_____i. Follow manufacturer's instructions when servicing motor gearcase and reducers

5. Select from the following list general maintenance procedures. Place an "X" in the blanks before correct statements.

_____a. Over-lubricate to be sure equipment is in good shape

_____b. Check hydraulic systems occasionally and be able to identify and correct malfunctions

_____c. Never run equipment except when necessary

_____d. Check operating pressures of equipment and if necessary, adjust to manufacturer's specifications

_____e. Check all tolerances, clearances, and gaging according to manufacturer's recommendations

_____f. Clean and replace filters every 5000 hours

MAINTENANCE
UNIT II

ANSWERS TO TEST

1. a. 8
   b. 5
   c. 7
   d. 10
   e. 9
   f. 3
   g. 11
   h. 1
   i. 12
   j. 4
   k. 6
   l. 2

2. Any eight of the following:
   a. Follow manufacturer's recommendations
   b. Always use matched sets from one manufacturer when replacing belts on multiple V-belt drives
   c. Always replace all belts on any one drive when replacement of a belt is necessary
   d. Never pry or roll belts on drive; always use drive take-up
   e. Lubricate take-up rails when necessary
   f. When installing leather belts always put the flesh side (rough side) on outside
   g. Clean belts and apply belt dressing whenever necessary
   h. When replacing a chain be sure to check sprockets as they probably are worn enough to need changing also
   i. Examine chains and sprockets to be sure they are positioned parallel and are in true axial alignment

j. Inspect chains regularly and clean if necessary, using a good solvent, then relubricate

k. Drain and change lubricants in all drive casings according to manufacturer's recommendations

l. Inspect steam turbines equipped with oil rings once during each shift

m. Check gear boxes equipped with sight level indicators at least once a day

3. Any eight of the following:

a. Inspect bearings, couplings, seals, packings, and stuffing boxes regularly and lubricate and/or replace as necessary

b. Replace bearings if they have streaks, spots, cracks, or etchings

c. Fit babbitt lined sleeve bearings and bearing shells, scraping very lightly so as not to remove too much metal at a time; check and fit occasionally until the correct clearance is obtained

d. Check couplings periodically (every six months) for wear and lubrication

e. Check hub separation when aligning or installing couplings on a shaft

f. Always maintain full engagement of gears on couplings having external gear teeth on hubs and internal gear teeth in the covers

g. Take extreme caution to obtain correct alignment when using rigid couplings

h. Check seals and packings periodically for leakage

i. Keep all surfaces clean and always use clean fluids when installing packings and seals

j. Exercise care when replacing damaged seals and seal parts in the order that has been determined by study of the equipment and not necessarily by the way they were removed

k. Never tighten lip-type packings excessively when installing as this may crush the lip and damage the packing

l. Consult packing manufacturers for specific clearance allowances when installing cup packings

m. When repacking stuffing boxes, be sure to remove all old packing, thoroughly clean box, and check all parts and piping to be sure they are not clogged before replacing new packing

n. Watch installation and break-in of seals carefully

   o. Never replace seals with old seals; when a seal is removed always replace with a new one

   p. Take extreme care when inspecting mechanical seals not to damage or distort the optically flat surfaces; clean all seal parts, especially the inside bores, before inspection

4. a, b, e, h, i

5. b, d, e

MILLWRIGHT INSTRUCTIONAL MATERIALS

PROGRESS CHART

Section J

Maintenance

Student's Name	UNIT I SAFETY PRECAUTIONS			UNIT II MAINTENANCE																
Job	1	2	3	1	2															
	Unit Test			Unit Test																
1																				
2																				
3																				
4																				
5																				
6																				
7																				

Accuracy

	85% Correct			85% Correct																
9																				
10																				
11																				
12																				
13																				
14																				
15																				
16																				
17																				
18																				
19																				
20																				

MILLWRIGHT INSTRUCTIONAL MATERIALS

PROGRESS CHART

Section J

Maintenance

Student's Name	UNIT I SAFETY PRECAUTIONS			UNIT II MAINTENANCE																
Job	1	2	3	1	2															
	Unit Test			Unit Test																
1																				
2																				
3																				
4																				
5																				
6																				
7																				

Accuracy	85% Correct			85% Correct																
8																				
9																				
10																				
11																				
12																				
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